Defense Exhibit No. 2—Continued.

WHEREAS, as of the date hereof, the Authority is ready, willing and able to consummate said transaction by the purchase of said urban distribution systems, and said Alabama Power Company has refused and now refuses to make said conveyance and has failed and refused to obtain said releases, as required by Section 3 of said Agreement, and

WHEREAS, said releases required by said Section 3 of said Agreement, dated August 9, 1934, as of the date hereof, are not ready and available for delivery;

NOW, THEREFORE, in consideration of the premises it is:

RESOLVED, that by reason of the aforesaid failure and refusal of the Alabama Power Company to have ready and available for delivery said releases required by said Agreement, dated August 9, 1934, or to make said conveyance conformably to the provisions of said Agreement, the Authority hereby withdraws from said Agreement of August 9, 1934, and said contract be, and it is hereby, cancelled, annulled and rescinded, and

RESOLVED, that Charles E. Hoffman, Assistant Secretary of the Corporation, be, and he is hereby, authorized and directed, upon behalf of the Authority, to notify said Alabama Power Company of the determination of the Authority to withdraw from said Agreement of August 9, 1934, and of the cancellation, annulment and rescission, by the Authority, of said Agreement."

I hereby certify that the foregoing is a true copy of a quotation which appears in the minutes of the above described meeting.

Charles E. Hoffman
Assistant Secretary

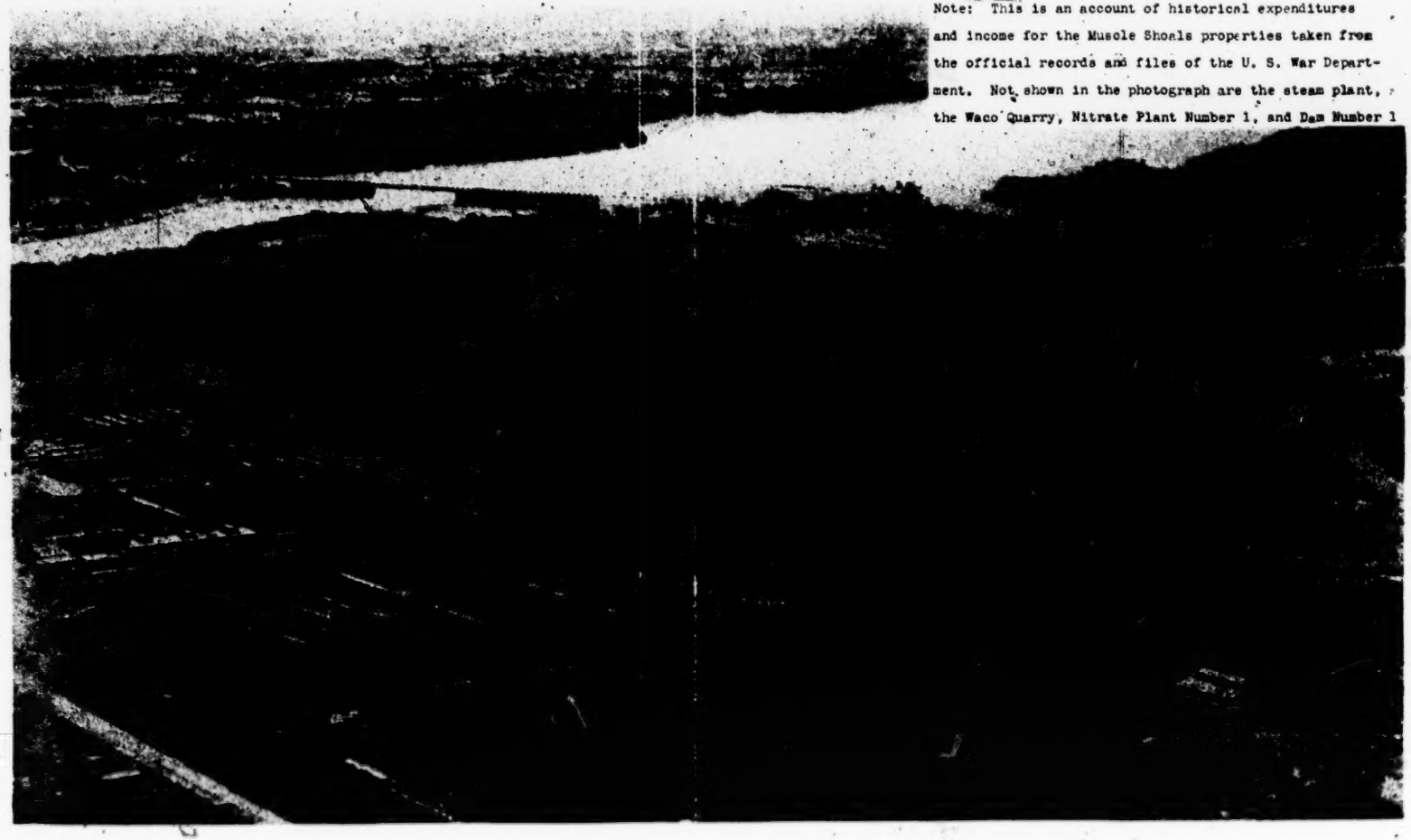
Defense Exhibit No. 8.

MUSCLE SHOALS - BASIC DATA BY J. L. NEELY

ITEMS OF HISTORICAL COST	
WILSON DAM	$ 46,950,748.36
STEAM PLANT	$ 12,326,392.23
PLANT NO.1	$ 13,757,807.00
PLANT NO.2	$ 58,855,134.34
WACO QUARRY GORGAS STEAM PLANT & TRANSMISSION LINE	$ 5,012,643.72
TOTAL HISTORICAL COSTS	$ 136,902,726.23

INCOME FROM GOVERNMENT PROPERTIES	
NITRATE PLANTS & WACO QUARRY STEAM PLANT-SALE OF GORGAS STEAM PLANT & TRANSMISSION LINE	$ 5,686,213.14
TRANSFER OF PROPERTIES TO GOVERNMENTAL AGENCIES	$ 3,779,659.21
INCOME FROM RENTALS, COLLECTIONS ETC	$ 59,858.93
REVENUE FROM HYDRO-PLANT 12/31/1934	$ 6,064,042.19
TOTAL REVENUE	$ 15,589,773.47

TOTAL UNABSORBED COST $ 121,312,952.76



Note: This is an account of historical expenditures and income for the Muscle Shoals properties taken from the official records and files of the U. S. War Department. Not shown in the photograph are the steam plant, the Waco Quarry, Nitrate Plant Number 1, and Dam Number 1

The properties owned by the United States at Muscle Shoals included Wilson Dam, with necessary locks, power houses, reservations, etc., U. S. Nitrate Plant #1 and the reservation, U. S. Nitrate Plant #2 and its reservation, and Waco Quarry which is located near Russellville, Alabama, and does not appear on the photograph. It is about five miles southeast of Russellville.

The Wilson Dam Properties, including locks, reservation dams, power houses, etc. have an historical cost of $46,950,748.36. U. S. Nitrate Plant No. 2, including plants and Waco Quarry has an historical cost of approximately $71,181,000.00 but for convenience I have shown the steam plant as $12,326,392.22 and Plant No. 2 and Waco Quarry at $58,855,154.34, and Plant No. 1 has an historical cost of $13,757,807.58. At the time the nitrate plants were built the Government also purchased and installed the Gorgas Steam Plant and transmission lines at a cost of $5,120,643.72, to obtain the power necessary to operate Nitrate Plant No. 2 pending the construction of Wilson Dam so that the total historical cost of the Government properties at Muscle Shoals was $136,902,726.23. The cost data information set forth in Exhibit No. 8 is correct and was obtained from the official records of the U. S. Ordnance Department and Engineers Department on file at Muscle Shoals.

$121,312,952.76 of the historical cost remains unabsorbed after revenues have been received. The revenues received represent the income from the Nitrate Plants, Waco Quarry, the sale of the Gorgas Steam Plant and transmission lines, collection of rents, etc. of $5,686,213.14; the transfer of arsenals, forts, etc. to other government agencies $3,759,659.21; income from rentals representing collections made by the Tennessee Valley Authority for house rentals, etc. $59,858.93; revenues from the hydro

plant through December 31, 1934, of $6,064,042.19, making a total revenue of $15,589,773.47. This information was likewise obtained from the records of the U. S. Engineering Department, the U. S. Ordnance Department and the Tennessee Valley Authority.

As early as 1824 President Monroe recommended that navigation be provided around Muscle Shoals as one of the three most important navigation needs of the country. As a result of this recommendation, a survey was made in 1826 and 400,000 acres of public land were donated to the State of Alabama, the proceeds of which were to be used in the construction of locks and canals around the Shoals. In 1836, the canal was completed, containing 16 locks, 32 feet in width and 120 feet in length, with a five foot depth. This canal was not a success since it constituted only the middle section of the Shoals, and since funds had been exhausted and there was no money available for the maintenance of the locks, the system fell into decay.

In 1871, as a result of the constant agitation, another survey was ordered by Congress as a result of which the canal was rebuilt by the United States Government. The number of locks was reduced to 11 with 9 on the outside of the river and 2 on the south side and the use of open canals wherever practicable. This work was completed in 1890, but was not a success because the locks were navigable only during the periods of high water. In 1899, Congress authorized the development of Muscle Shoals for power and directed the U. S. Engineers to call for bids. Several bids were submitted, the most noteworthy of which was that of the Muscle Shoals Hydro Electric Power Plant. After submitting several bids which were not acceptable to the United States Engineers this Company finally submitted an acceptable bid late in 1915 or

early in 1916. At this time however the army engineers ruled that further discussions be discontinued in view of the passage of the National Defense Act in 1916.

In 1916 it became apparent that the United States would become involved in the European war and, because of Germany's submarine policy, it was necessary to obtain a supply of nitrates independent of that of Chile and South America. The United States has no nitrate supply minerally and it was necessary to secure nitrates by some other method. Section 124 of the National Defense Act of 1916 authorized the President to make investigations with a view to the development of plants and the generation of electric energy for the manufacture of munitions in time of war and fertilizer in time of peace, including the location of adequate sites. President Wilson appointed two committees, one to select the site, and the other to select the best means of producing nitrate. Muscle Shoals was one of the four sites recommended by the Committee for the establishment of a nitrate plant, and in September, 1917, the construction of Nitrate Plant No. 1 at Sheffield, Alabama, was authorized. Nitrate Plant No. 2 was begun about the same time, and the President also allocated $500,000.00 from funds made available by the National Defense Act for the acquisition of lands and the beginning of construction of the dams and locks at Wilson Dam. Work on the dam was prosecuted until 1921, at which time it was discontinued for lack of funds. In July, 1922, Congress appropriated funds for the continuation of the work, and the dam was completed in September, 1925. From the date of its completion until September, 1933, when it was taken over by the Tennessee Valley Authority, Wilson Dam was operated and maintained by the United States Army Engineers. During this period it furnished current for the operation of locks and the

reservation and also supplied current to the Alabama Power Company under the existing contract. Nitrate Plant No. 2 was successful, but Nitrate Plant No. 1 was not. Both plants were maintained in standby condition by the United States Ordnance Department along with Waco Quarry.

The total cost of maintenance of Nitrate Plants 1 and 2 and Waco Quarry up to June 30, 1933, was approximately $1,095,000.00 or $91,300.00 annually. Wilson Dam was maintained and operated at a cost of approximately $1,884,000.00 or an annual cost of approximately $157,000.00.

Under date of October 29, 1919, Newton Baker, while Secretary of War, wrote a letter to James W. Wadsworth, Chairman of the Senate Committee on Military Affairs, in which he transmitted a proposed bill providing for a government owned corporation which would control and operate the Muscle Shoals properties in the interest of National Defense and Agriculture. The substance of the letter is as follows:

> I shall be grateful if you will introduce the enclosed bill in the Senate. It proposes operation of the Muscle Shoals property by a corporation in which the government will be the sole stockholder. The choice of such an instrument is dictated by the greater freedom with which the commercial and scientific undertakings of the plant can be carried on under such circumstances. I believe we should spend the additional sums necessary to equip the plant for the production of nitrogen for fertilizer, thereby aiding the farmer and maintaining the properties as a military asset for the production of nitrogen for explosives.

In March, 1921, Secretary of War Weeks stated that when a proposition was made for the disposition of Muscle

Shoals promising commercial results commensurate with the expenditure, he would feel required to transmit the offers to Congress. Several offers were made, the most noteworthy of which was that of Henry Ford. Ford's offer provided for the formation of a corporation to which the United States Government should turn over in fee simple the properties of the U. S. Nitrate Plants No. 1 and No. 2, including the reservation, Waco Quarry, and the Government's interest in the Gorgas Steam Plant and transmission lines. He further agreed to pay 4% interest on the cost of the construction of Wilson Dam, excluding that portion already expended or approximately $17,000,000.00, but for the first three years following the completion of the dam to pay $200,000.00 a year as rental in lieu of the 4% interest. This figures about ½ of one per cent. His offer also required the construction by the Government of Dam #3, or Wheeler Dam, and he offered to pay on the cost of this construction 4% interest, but for the first three years following its completion to pay $150,000.00 per year in lieu thereof. Ford agreed to make fertilizer at full capacity during the time of the lease to the Corporation. Several other proposals were submitted in 1924, including proposals by the Alabama Power Company and associates, and the Union Carbide Company. Messrs. Hooper and White submitted a proposal for a Manganese Corporation, the expenses to be borne by the Government.

In February, 1924, and again in April, 1924, Senator Norris introduced a bill for Government operation of the properties. In 1925, President Coolidge appointed a five man committee to arrange for the disposition of the properties in accordance with the conditions of the National Defense Act of 1916. The Committee report in November, 1925, recommended government operation if no private lessee could be found who would guarantee public operation

of these properties with respect to National Defense and agriculture.

In 1926, the American Cyanamide Company, acting with the Air Nitrates Corporation, made a proposal similar to that of Ford, except that they reserved the right to use surplus power for purposes other than the manufacture of fertilizer.

In 1927, Congress passed Senate Joint Resolution #46 providing for experimental work, the manufacture of fertilizers, and the sale and transmission of surplus power. This bill was vetoed by President Coolidge in 1928. A similar bill presented in Senate Joint Resolution #49 was passed by Congress and vetoed by President Hoover in 1931. The Tennessee Valley Authority Act was passed in May, 1933, authorizing the Tennessee Valley Authority to take over the properties for operation. (At this point a list of official documents pertaining to the Muscle Shoals properties were introduced in evidence as defense Exhibit #9. This Exhibit is omitted.)

Upon **Cross Examination**, the Witness Testified as Follows:

Nitrate Plant #2 is operated by the Cyanamide Process and Nitrate Plant #1 by the synthetic process. Tennessee Valley Authority is using certain portions of Nitrate Plant #2 in the manufacture of phosphate fertilizer. Such portions as are not being used are being maintained in standby condition. Certain units are being converted by the introduction of the electric furnace for smelting of phosphate rock and manufacturing phosphate fertilizer. The Authority is proposing to dispose of the fertilizer so manufactured in accordance with the Act which provides that it may be distributed through cooperative farm organizations. The conversion of nitrate units and cyanamide units

to the use of electric smelting of phosphate does not necessitate the entire reconstruction of the plant, or the permanent withdrawal of those units from the manufacture of nitrates. The plant could be reinstalled in its original condition in about a month.

I am not familiar with the items set forth in the answers to interrogatories showing anticipated revenues from fertilizer operations, but I know that such revenue is not expected to be derived from the sale of fertilizer.

The nitrate plants are not obsolete, but they are not being used at the present time for the production of nitrates. They could be used in case of war.

Phosphate fertilizer is more important to the farmer than nitrate because nitrogen can be obtained from legumes produced by the soil. I am not familiar with the cost of nitrogen manufactured at Muscle Shoals as compared with commercial nitrogen from the commercial plants throughout the United States.

The Government disposed of its Gorgas Steam Plant and transmission lines in September, 1924.

The action of January 25 is the first action taken by the Board of Directors with reference to the contract of August 9. The resolution was not adopted in my presence, but was sent to me by the Assistant Secretary. I do not recall anything in the minutes as to Mr. Lilienthal's conferences in Washington for the purpose of obtaining execution of Public Works Administration loans or relating to that matter.

I am not familiar with any negotiations of the Tennessee Valley Authority for the purpose of securing additional transmission lines, nor am I familiar with any plan and program with reference to the main river dams and tributary dams carried in the current budget reports.

In addition to acting as custodian of the records and

minutes of the Authority, I am in general charge and manager of the operations of the Muscle Shoals properties. I am not in charge of the electric policies of distribution.

I am not familiar with the current construction program of rural electrification in north Alabama because it is not connected with the Muscle Shoals properties, nor am I familiar with the construction of the parallel line between Wilson Dam and the Mississippi State line.

In my historical comments I did not refer to the appointment of the Muscle Shoals Commission which was established by the concurrent acts of the legislatures of Alabama and Tennessee and created by President Hoover although I have read as much of their report as I could.

Included in the revenues which I gave on direct examination were all revenues through December 31, 1934, and included in that year are the revenues derived by Tennessee Valley Authority from the sale of power to the Alabama Power Company and other companies, and income from rental collections, water collections, etc. from the reservation.

I do not know whether the figures of $4,600,000 expected income for the year 1936 set out in the budgetary request included income from the direct sale of power. I am not familiar with the basis of that estimate, nor am I familiar with the details of the interchange agreements between the Tennessee Valley Authority and the Alabama Power Company and the Carolina Power and Light Company.

Upon **Re-direct Examination** the Witness Testified as Follows:

Tennessee Valley Authority has approximately 7,000 of its 13,000 employees in the State of Alabama.

C. T. BARKER,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as follows:

I am an hydraulic engineer. I graduated from the University of Minnesota in 1922. For four years prior to April, 1928, I was engaged in the investigation of navigation, flood control and hydro-electric problems in the preparation of H. D. 328, with the U. S. Engineering Department at Chattanooga. During this period, I was successively a junior draftsman, computer and designer of analysis of navigation, flood control and hydro-electric structures, assistant to the chief engineer in charge of the preparation of all hydraulic, hydrographic and preliminary design data entering into a complete analysis of the water resources of the Tennessee River basin.

From May, 1928, to August, 1932, I was engaged in the preparation of reports under H. D. 308 with the U. S. Engineering Department, at Kansas City, Missouri. During this time, I was successively engineer on the Platte River in charge of field surveys with relation to irrigation, flood control and water power, assistant to the chief of the flood control division and in direct charge of the design of flood control projects and the preparation of reports dealing with flood control, irrigation, navigation and water way problems on the Missouri River and its tributaries.

From September, 1932, to March, 1933, I was engineer in charge of the U. S. Engineers Office at Sioux City, Iowa, supervising construction of navigation improvements on the Missouri River.

From April to November, 1933, I was engineer in charge of hydraulic and civil engineering section of the U. S. Engineering Department at Wilson Dam, responsible for the preparation of studies and reports upon hydraulic

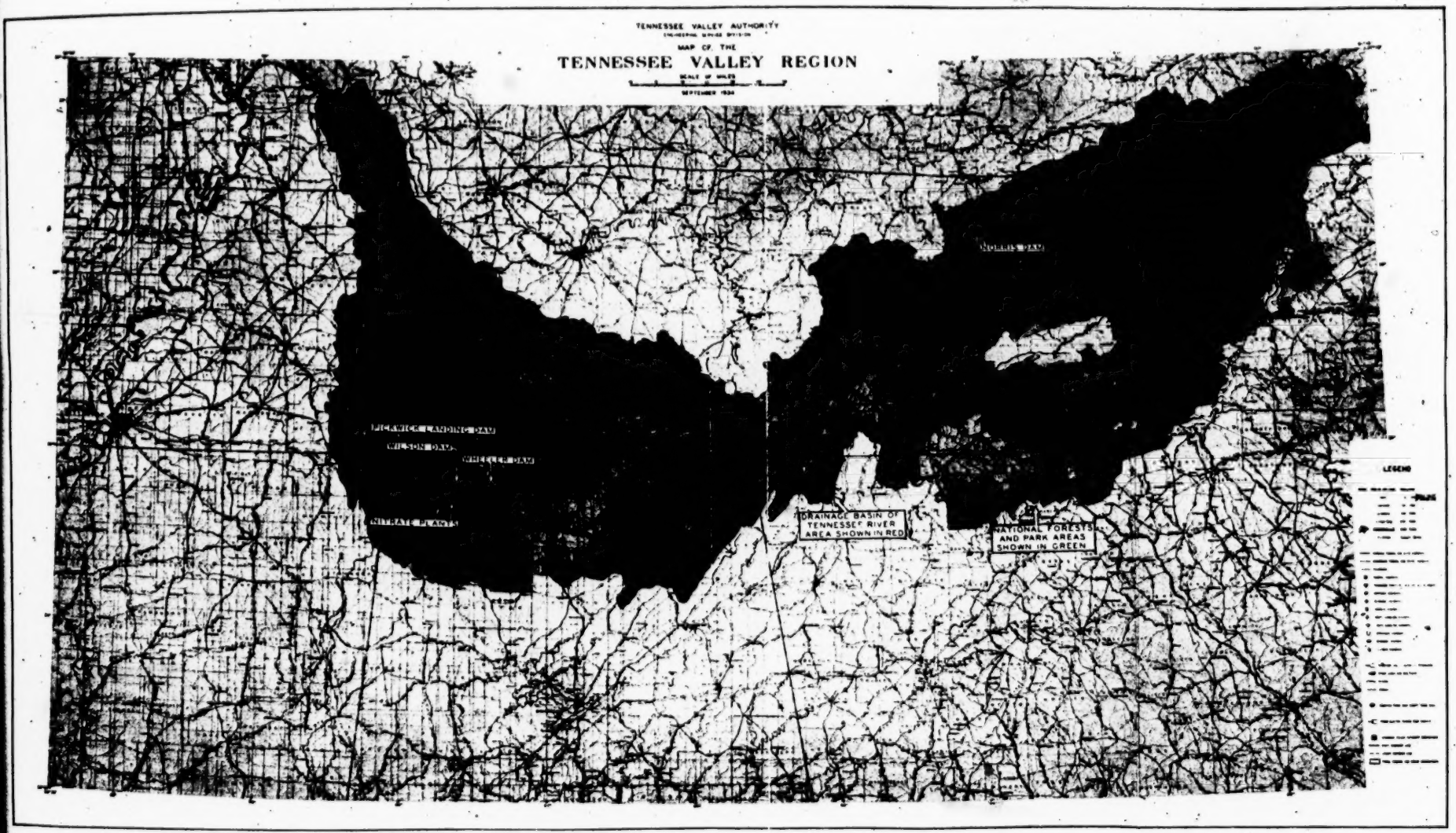
problems, hydrographic surveys and improvements of navigation on the Tennessee River from Hale's Bar to Riverton, Alabama.

Since December, 1933, I have been engineer in charge of navigation section of the Tennessee Valley Authority, engaged in the study and preparation of reports on navigation problems on the Tennessee River. In the course of that work, I made a rather complete study of the Tennessee River and its physical characteristics. (The witness here identified a map entitled "Tennessee Valley Authority, Map of the Tennessee Valley Region," which was introduced in evidence as Defense Exhibit No. 10, a reproduction of which appears upon the opposite page). This map correctly portrays this region.

The Tennessee River is formed by the junction of the Holston and French Broad Rivers about four miles east of Knoxville. It flows in a generally southwesterly direction past Knoxville, Lenoir City and Chattanooga, in the State of Tennessee, and on into northern Alabama to Guntersville, which is the most southern point. From that point, it turns and goes generally westerly past Decatur, Florence and Sheffield to the Tennessee State line, and turns abruptly north and flows almost due north across Tennessee and part of Kentucky to join the Ohio River at Paducah, Kentucky, which is about 45 miles from Cairo, which is at the junction of the Ohio and Mississippi Rivers. It is 647.7 miles from Paducah to Knoxville.

The Tennessee River drains part of seven states—Kentucky, near the mouth of the river, a large part of Tennessee, the southwestern part of Virginia, the eastern part of North Carolina, a small area in the northern part of Georgia, a good deal of the northern part of Alabama and a small amount of the northeastern part of Mississippi.

Defense Exhibit No. 10.



The main tributaries, starting on the north side of the river at the mouth and going around in a clockwise direction, are the Duck River, the Elk River, the Sequatchie River, the Upper Clinch System, which includes the Emory, the Holston, the French Broad, which includes the Nolachucky and Pigeon Rivers, the Little River on the south side just below Knoxville, the Little Tennessee, the Hiawassee, and Bear Creek.

The more important natural resources in the basin are coal, phosphate rock, asphalt rock, sand, gravel, clay, limestone, marble, iron, copper and zinc ores, bauxite, feldspar, manganese, barite, slate and forest products. The chief agricultural commodities of the area are cotton, corn and tobacco and of lesser importance are small grains, fruits, vegetables, live stock, dairy products, and the general run of farm products. The most important manufactured commodities are cotton and yarn textiles, manufactured iron and steel articles, aluminum, finished marble, lumber and other wood products and paper.

The low water elevation at Knoxville is about 802 feet, and at Paducah, about 648 miles below, it is 302 feet. Beginning at Knoxville and continuing downstream, the slope of the river varies greatly from a gentle slope to a very steep slope. From Knoxville to Chattanooga, there is rather a gentle slope except at certain places where there are steep rapids or shoals, and in those places the slope is as much as 15 feet to the mile. From Chattanooga to Hale's Bar, the natural slope of the river is about 1 foot to the mile, but it has been very largely corrected by Hale's Bar Dam. From Hale's Bar to the head of Brown's Island, which is just west of Guntersville, there is a gentle slope averaging about .42 of a foot to the mile. From the head of Brown's Island to Florence Bridge, a distance of

about 37 miles, there is a slope of about 134 feet, which is the steepest slope in the whole river. From Florence to the head of Colbert Shoals, there is a rather gentle slope of about .62 foot to the mile. Over Colbert Shoals, there is a very steep slope of about 26 feet in 10 miles, and from the foot of Colbert Shoals at Riverton and continuing to Paducah, there is a gentle slope averaging about .32 of a foot to the mile.

Due principally to the variation of rainfall, the stream flow varies a great deal seasonally. The rainfall of the basin as a whole averages about 51 inches and in the mountainous regions of East Tennessee and North Carolina it is extremely heavy, running as high as 80 inches. The stream flow in the summer months runs as low as 8,000 to 10,000 second feet at Florence and around 2,000 second feet at Knoxville. In the winter months, at Florence, it commonly runs between 100,000 and 200,000 second feet, perhaps as high as 400,000. The greatest flood of record at Florence is 440,000 second feet. At Knoxville, high-water flow has reached around 195,000 second feet. The term second feet means cubic feet of water per second.

The variation in the stream flow creates numerous navigation problems. It is very difficult to predict what the flow will be in the summer months. Navigation might be good for month or so, and then the flow will drop off and navigation will be poor for a month or two. The stream will then rise again and navigation will be good for awhile. High flow creates a great many problems in flood control as the water inundates valuable areas of land and destroys property.

Beginning at the month of the river at Paducah, Kentucky, and coming up to Riverton, there are very few

obstructions except for occasional bars and reefs. At Riverton there is a very great obstruction due to the shoal formation at Colbert Shoals which is almost a waterfall. In the section below Florence there are some rock reefs and bars which obstruct navigation. Just above Florence are the big Muscle Shoals and little Muscle Shoals which are the greatest natural obstruction in the entire river. The slope is very steep, and is again almost a natural waterfall. In the middle of the river at this point are a great number of bars and reefs, and the shallow depth makes navigation very difficult. Before the completion of the dam at Widow's Bar, a natural obstruction existed at that point and there were also several very serious obstructions in the Hale's Bar pool between Kelly's Bar and Chattanooga. Between Chattanooga and Knoxville are a number of reefs and bars over which the velocity is very swift. (The witness then identified a chart entitled "Previous Projects, Tennessee River Basin, Basic Data by C. T. Barker," which was introduced in evidence as Defense Exhibit No. 11, a reproduction of which appears upon the opposite page).

The first Congressional appropriation for improvement of the Tennessee River was made in 1852, and the project covered the river between Knoxville and Kelly's Ferry, which is just below Chattanooga, a distance of something over 200 miles. The project depth was 2 feet by open channel improvement. The next project was in 1868 from Chattanooga to Decatur. The project depth was 3 feet by open channel improvement. In the same year, a project was begun for a 3 foot depth by open channel improvement from Florence to Riverton and from Riverton to Paducah. In 1871 a project was adopted from Elk River Shoals to Florence for a 6 foot canalized development. In

1872 a 3 foot open channel project was adopted from Knoxville to Chattanooga. In 1890 a 7 foot canalized project from Colbert Shoals to Riverton was adopted and in the same year a 5 foot open channel project from Riverton to Paducah; in 1894, an open channel improvement was begun from the head of the river to Chattanooga with no project depth specified.

In 1904 and 1905 a 6 foot slack water development from Hale's Bar to Chattanooga was adopted; in 1907, a 5 foot open channel project from Scott's Point, which is above Hale's Bar to Lock A at the mouth of the Elk River; in 1910, a 5 foot open channel project from Florence to Colbert Shoals; in 1912, a 3 foot open channel project from the head of the river to Caney Creek Shoals down to the mouth of the Clinch River; also in 1912, Caney Creek pool which provided a 6 foot canalized development by a dam near the mouth of the Clinch River, a 3 foot open channel project from Caney Creek to Chattanooga, and a 5 foot open channel project from Hale's Bar to Florence and from Riverton to Paducah. In 1918, the Wilson Dam project was adopted which gave a 9 foot slack water development for 15 miles above Florence and in 1925, the Florence Canal was constructed by means of lock and dam No. 1 above Florence Bridge, which gave a 9 foot canalized development. The foregoing are all the principal projects which had been adopted prior to the passage of the Tennessee Valley Authority Act.

The construction of Wilson Dam accomplished a very great improvement to navigation by providing a slack water development over the worst spot in the river, Muscle Shoals Rapids, which were practically impossible to pass on the upstream haul, and very difficult to pass going downstream. A small canal had previously been con-

structed at this point which was of very little use and was flooded out by Wilson Dam.

By slack water development, I mean the forming of a pool behind the dam in which there is very little current.

The attempt to make the Muscle Shoals area substantial utility for navigation had failed up to the time of Wilson Dam.

The height of Wilson Dam from normal lower pool to normal upper pool is 89 feet. By normal lower pool, I mean the navigation channel which was formed by lock and dam No. 1, that elevation being about 416 feet above sea level. This is the normal elevation of the lower pool. The normal elevation of the upper pool is 505 feet, and the difference between them is 89 feet. To accomplish the same benefits to navigation, it would be necessary to build a series of low dams, one above the other in a series of steps, or it would be necessary to build a confined canal along one of the banks, and by a series of locks in the canal which would also carry navigation upstream in a series of steps. The canal system is not satisfactory. It was very difficult to get through the existing canal. There were 9 small locks in it and it would have been impracticable to widen the canal and put in larger locks. About 6 locks and dams would have been necessary to take the place of Wilson Dam for navigation purposes.

Following is the status of navigation on the Tennessee River prior to the time when Tennessee Valley Authority began operations.

Starting at the mouth of the river and proceeding upstream, navigation was not very difficult to Riverton lock at Riverton, Alabama. There were a few bars and shoals, but navigation was not extremely difficult. At Riverton it was necessary for navigation to pass through the small

Riverton lock which is about 80 x 287 feet. Navigation would then continue above the lock through Colbert Shoals Canal, in slack water, for a distance of 8 or 9 miles. The boat would then come into the open river and would have to pass over Buck Island Shoals and Tuscumbia Bar, which are both very serious obstructions. The low water depth is only about 4 feet and the velocity is very swift. The boat would then enter lock and dam No. 1 at Florence Bridge and would continue up Florence Canal, a distance of about 2½ miles to Wilson Dam.. It would then pass through the Wilson Dam lock and proceed up Wilson Lake, a distance of about 15 miles. It would then enter the small lock No. 2 of the Muscle Shoals Canal and would continue up the old canal through lock No. 1. The boat would then enter the open river again and proceed upstream to the mouth of Elk River, and go through Locks B and A of the Elk River Shoals Canal. The controlling depth through that stretch is about 3 feet at the present time. It would then continue in the open river to Widow's Bar with a 3 foot controlling depth all the way. Passing through Widow's Bar lock, the boat would proceed in the Widow's Bar pool where the controlling depth is about 4½ feet, and would then go through Hale's Bar lock and proceed in Hale's Bar pool to Chattanooga with a controlling depth of about 6 feet.. From Chattanooga to Knoxville is open river. There have been some open river improvements, but no canalization, and controlling depths are about 1 foot. (The witness here identified chart—"Existing and Proposed Channel Depths before Tennessee Valley Authority Act, by C. T. Barker." This was introduced in evidence as Defense Exhibit #12, a reproduction of which appears upon the opposite page).

Exhibit #12 shows a comparison between the present

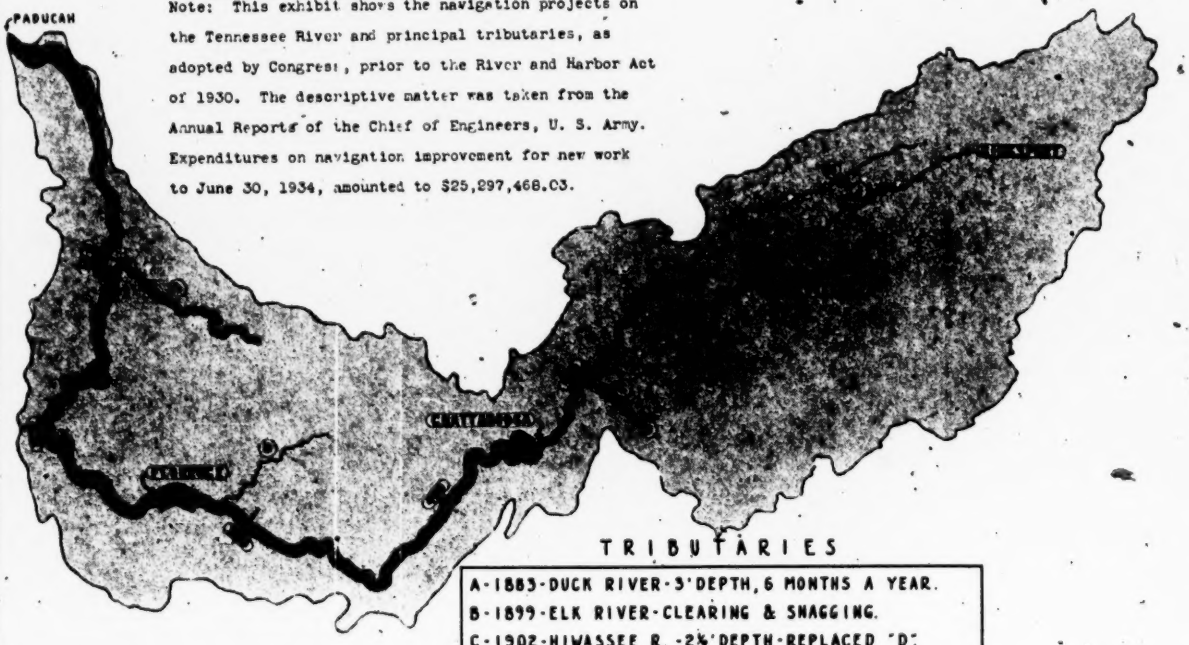
Defense Exhibit No. 11.

PREVIOUS PROJECTS TENNESSEE RIVER BASIN -- BASIC DATA BY C.T BARKER

TENNESSEE RIVER

YEAR	MILEAGE	LOCATION	DEPTH
1852	647-442	KNOXVILLE-KELLYS FERRY	2' O.C.
1888	464-305	CHATTANOOGA-DECATUR	3' O.C.
"	257-227	FLORENCE-RIVERTON	3' O.C.
"	227- 0	RIVERTON-PADUCAH	3' O.C.
1871	290-260	ELK R. SHOALS-MUSCLE SHOALS	6' C.
1872	647-464	KNOXVILLE-CHATTANOOGA	3' O.C.
1890	235-227	COLBERT SHOALS-RIVERTON	7' C.
"	227- 0	RIVERTON-PADUCAH	5' O.C.
1894	652-464	HEAD OF RIVER-CHATTANOOGA	0' O.C.*
1904 1905	464-431	CHATTANOOGA-HALES BAR	6' S.W.
1907	431-286	SCOTT POINT-LOCK "A"	5' O.C.
1910	257-235	FLORENCE-COLBERT SHOALS	5' O.C.
1912	652-585	HEAD OF R.-CANEY CR. POOL	3' O.C.*
"	585-560	CANEY CREEK POOL	6' C.
"	560-464	CANEY CR. POOL-CHATTANOOGA	3' O.C.*
"	431-257	HALES BAR-FLORENCE	5' O.C.
"	227- 0	RIVERTON-PADUCAH	5' O.C.
1918	279-259	WILSON DAM POOL	9' S.W.
1929	259-257	FLORENCE CANAL	9' C.

NOTES. "O.C." INDICATES "OPEN CHANNEL"; "C" IS "CANALIZED"; & "S.W." IS "SLACK WATER."
* EXISTING 9' PROJECT ABANDONED.
* PREVIOUS 9' PROJECT REINSTATED.
THE 9' DEPTH SHOWN FOR A DISTANCE OF 45 MILES UP FROM THE MOUTH OF THE RIVER IS SLACK WATER BEHIND OHIO RIVER DAM Nº 52, AUTHORIZED IN 1910. PROJECT DEPTHS IN FORCE IN 1930 SHOWN BY LATERAL SCALE OF 1"=20" HEREON.



NOTE: MILEAGE ABOVE PADUCAH SHOWN (200)

Previous Projects, Tennessee River Basin

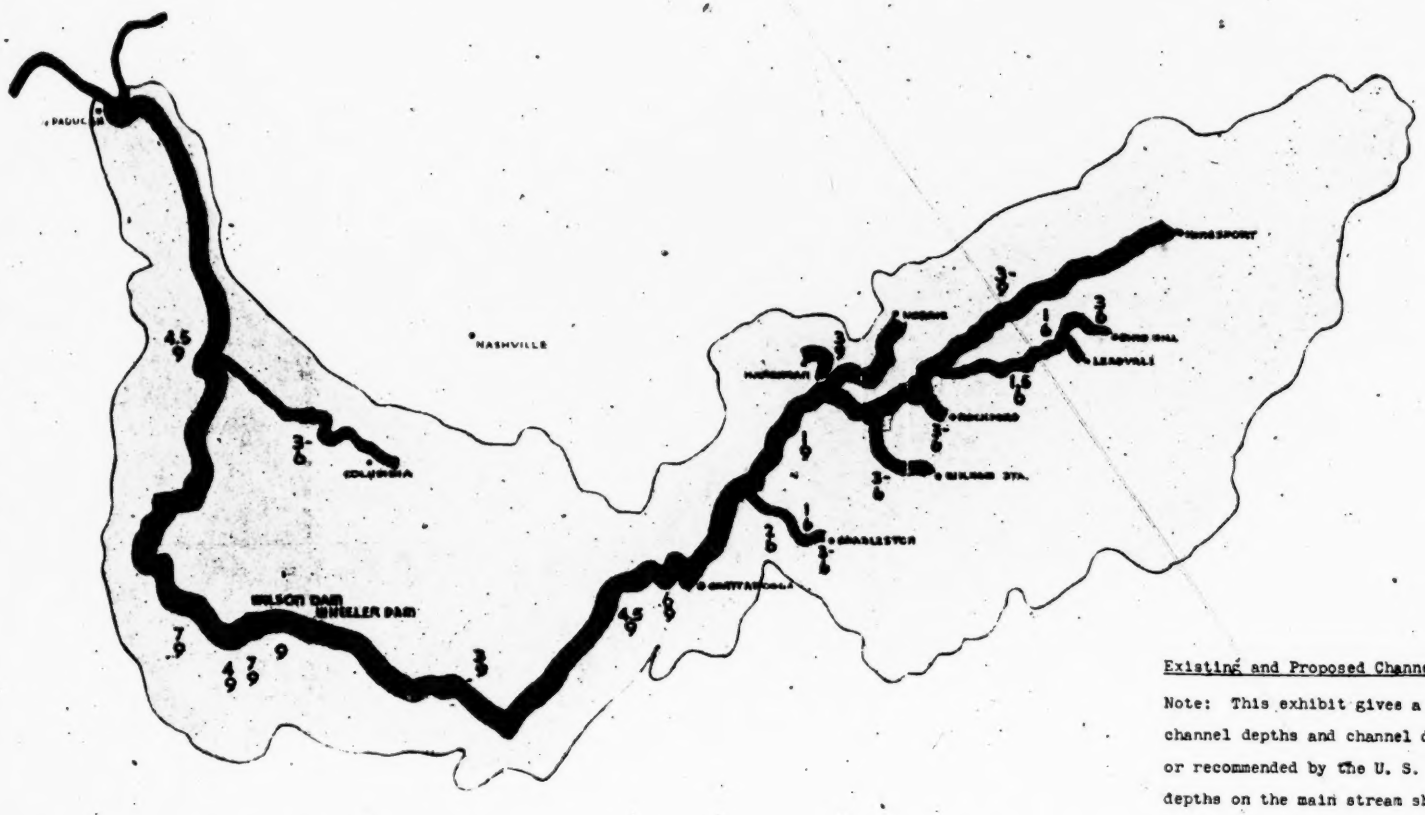
Note: This exhibit shows the navigation projects on the Tennessee River and principal tributaries, as adopted by Congress, prior to the River and Harbor Act of 1930. The descriptive matter was taken from the Annual Reports of the Chief of Engineers, U. S. Army. Expenditures on navigation improvement for new work to June 30, 1934, amounted to $25,297,468.03.

TRIBUTARIES

A-1883-DUCK RIVER-3'DEPTH, 6 MONTHS A YEAR.
B-1899-ELK RIVER-CLEARING & SNAGGING.
C-1902-HIWASSEE R.-2½'DEPTH-REPLACED "D"
D-1876- DO. 2'DEPTH-ABANDONED IN 1902.
E-1882-LITTLE TENNESSEE-2'DEPTH.
F-1880-CLINCH RIVER-2'DEPTH.
G- " DO 1½' "
H- " DO CLEARING & SNAGGING.
J-1902-1907-HOLSTON R.- DO.
K-1880-FRENCH BROA. R.-2½'DEPTH.

Defense Exhibit No. 12.

EXISTING AND PROPOSED CHANNEL DEPTHS BEFORE TENNESSEE VALLEY AUTHORITY ACT-BY C.T. BARKER.



4.5 —— PRESENT CHANNEL DEPTHS

9 ▬ MAIN RIVER CHANNEL DEPTHS ADOPTED IN RIVERS AND HARBORS ACT OF 1930. CERTAIN TRIBUTARY CHANNEL DEPTHS RECOMMENDED BY ARMY ENGINEERS IN HOUSE DOCUMENT 328.

Existing and Proposed Channel Depths

Note: This exhibit gives a comparison between present channel depths and channel depths authorized by Congress or recommended by the U. S. Army Engineers. The present depths on the main stream show great variation, with controlling depths as low as 3 feet below Chattanooga and 1 foot between Chattanooga and Knoxville. Existing depths on tributaries vary from 1 to 3 feet. The River and Harbor Act of 1930 authorizes a 9-foot depth on the main stream and the Army Engineers recommend 6 to 9-foot depths on the principal tributaries (H. D. 328). Data obtained from H. D. 328 and Annual Reports of the Chief of Engineers, U. S. Army.

channel depth and the channel depth authorized by Congress or recommended by the United States Army Engineers. Beginning at Knoxville and proceeding downstream, the controlling depth is only one foot to Chattanooga. From Chattanooga to Hale's Bar, the present controlling depth is 6 feet. Between Hale's Bar and Widow's Bar, the controlling depth is 4½ feet and from Widow's Bar to the head of Wilson Dam pool, the controlling depth is 3 feet. By controlling depth I mean the minimum at low water. In Wilson Dam pool, the controlling depth is 9 feet. From Wilson Dam to lock and dam No. 1, at the Florence Bridge, the controlling depth is 7 feet. From Florence to the head of Colbert Shoals Canal, it is 4 feet, and in the Colbert Shoals Canal, 7 feet. From Riverton lock to Paducah, the controlling depth is 4½ feet. In the Duck River, the principal lower tributary, the controlling depth is less than 3 feet. This is true also of the Clinch, the Holston, and the Nolachucky, the Little River and the Little Tennessee. On the French Broad, the controlling depth is about 1½ feet. On the Hiawassee it is about 2 feet in the lower portion, and 1 foot in the upper portion.

The proposed depth by the presently adopted project authorized by the Rivers and Harbors Act of 1930, is 9 feet from Paducah to Knoxville. The proposed depths on the tributaries are 6 feet on the Duck River, the French Broad, the lower parts of the Little River, the Little Tennessee and the Hiawassee, and 9 feet on the Holston River to Kingsport and on the lower part of the Clinch and Emory. The proposed depths on the main stream are those recommended by H. D. 328—on the tributaries, they represent recommendation of the Army Engineers and other documents.

It would not be practical from a navigation standpoint to develop the Muscle Shoals section with a series of low dams as you would probably have six low dams in a fifteen mile stretch and traffic would be greatly delayed. A high dam was the only feasible method of improving navigation in this stretch. (Here the witness identified a chart entitled "Plate 64, Corps of Engineers, U. S. Army," and also further entitled, "Tennessee River Survey of Terminals.") This chart shows the location of existing terminals on the Tennessee River. About fifty corporations and individuals have terminals along the stream. By terminals I mean wharves, warehouses and gantry cranes which would unload on the platform and, in some cases, power derricks. A number of terminals are located at Knoxville and Chattanooga and other points. Most of the traffic is necessarily in short stretches, separated one from the other.

I have prepared a table showing the annual traffic on the Tennessee River since 1891. This tabulation is based on the figures in the annual reports of the Chief of Engineers of the U. S. Army. From 1891 to 1894, the tonnage averaged about 500,000 tons. From 1895 to 1925, it runs between 1,000,000 and 1,600,000 tons. The values ranged from $27,000,000 to less than $1,000,000. In 1926 there was a slight increase in traffic. It ran over 2,000,000 tons a year through 1930. In 1931 it fell off a little, and in 1932 it fell off a good deal. (This tabulation was introduced in evidence as Defense Exhibit #14, which is omitted from this narrative.)

The obstructions in the stream are the principal reason why navigation is in short stretches. Most of the traffic would be through traffic were it not for these obstructions. Through traffic from Knoxville to Paducah is not com-

mercially feasible at present due to channel conditions. It would be possible in parts of each year. (The witness then identified a chart entitled "Plate 61, Corps of Engineers, U. S. Army," further entitled, "Tennessee River Tonnage During the Year 1926.")

This chart was prepared in connection with the House Document 328 study. It indicates that there is considerable traffic from Sheffield, Alabama, to the mouth, consisting of pig-iron, forest products and farm products, and other miscellaneous commodities. From the head of Wilson Dam to the Elk River Shoals Canal, there is practically no traffic. Navigation in this stretch is very difficult due to the obstructions. Around Decatur there is a little increase in the local traffic and there is considerable rafting of ties and logs into the wood products mills at Decatur. At Guntersville there is quite a little traffic between Guntersville and Hobb's Island due principally to the L. & N. Railroad car ferry. Between Guntersville and Chattanooga, there is only a little traffic. There is some in the Hale's Bar pool and quite a little right at Chattanooga, consisting principally of local sand and gravel. Between Chattanooga and the mouth of the Clinch, there is very little traffic due principally to the poor navigation conditions in the present channel. Near the mouth of the Clinch River, between Caney Creek and Kingston, there was quite a little traffic until within the last few years, due to the activities of the Roane Iron Company. There is practically no traffic from the mouth of the Clinch to Knoxville, but right at Knoxville there is a great deal of traffic, principally in sand and gravel from the local concerns. (The chart referred to above was then introduced in evidence as Defense Exhibit #15, which is omitted from this narrative.)

Up to the present time, traffic has been mostly in small,

flatbottomed barges around 200 or 300 and up to 500 tons, and stern wheel towboats principally steam, but some with Diesel motors. If a 9 foot channel is provided from Knoxville to Paducah, much larger barges can be used for ordinary commercial purposes, ranging up to 1000 or perhaps 1500 tons, and large towboats probably of the propeller or tug type. There might also be self-propelled barges running around 2000 or perhaps 2500 tons. The completion of the 9 foot depth from Knoxville to Paducah will give a continuous 9 foot navigable stream through the Mississippi and Ohio Rivers, and will accomodate the type of vessels that customarily operate on those rivers.

At the time Tennessee Valley Authority started its operations, it was necessary to improve the channel in practically every part of the river, except the Wilson Dam pool, to secure the 9 foot depth. Various studies have been made by the Army Engineers looking toward the general improvement of the river. These reports are embodied principally in House Document 319, 67th Congress, 2nd Session; House Document 463, 69th Congress, 1st Session; House Document 185, 70th Congress, 1st Session; House Document 328, 71st Congress, 2nd Session.

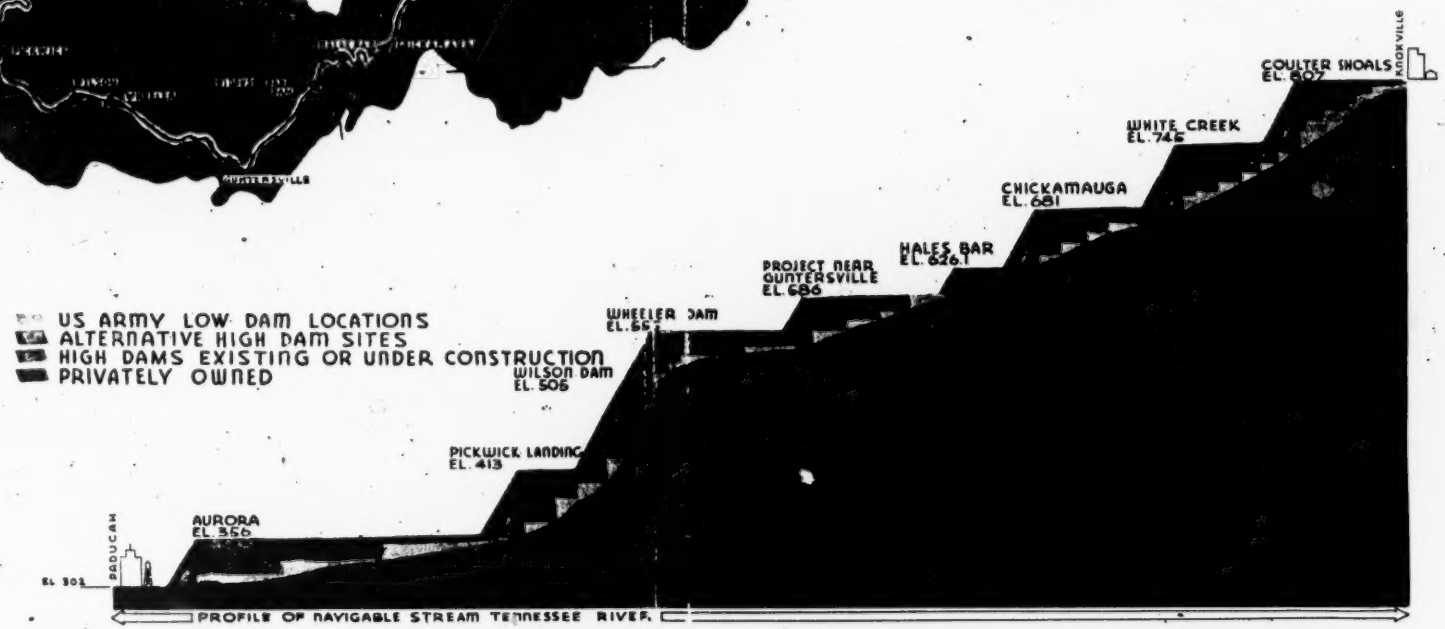
The last recommendation of the Army Engineers was for a 9 foot channel from the mouth to Knoxville. They suggested either a low dam plan consisting of a series of 32 low dams in addition to the dams which now exist, or as an alternative, 7 high dams in addition to the existing dams. (The witness here identified a chart entitled "Navigation Program for the Tennessee River, Basic Data by C. T. Barker." This chart was introduced in evidence as Defense Exhibit #16, a reproduction of which appears on the opposite page.) The low dams are shown in green and the high dams in yellow. (Upon reproduction low dams are in light shading and high dams in heavy.) The

Defense Exhibit No. 16.

NAVIGATION PROGRAMS FOR THE TENNESSEE RIVER - BASIC DATA BY C.T. BARKER

A series of high dams for navigation has many advantages over a low-dam plan. The high-dam plan would save a total of 11½ hours on the trip from the mouth to Knoxville, Tenn., a distance of about 650 miles. A total of $1,065,000 also would be saved in annual operation and maintenance charges. Slack water from the high dams would extend up the tributaries for considerable distances, thus reducing the cost of navigation improvements on these tributaries. The more stable pool levels furnished by the high dams would reduce first costs and operating charges on terminal developments by eliminating the great fluctuation always experienced in low-dam pools. In the high-dam pools, a large fleet could follow a direct course instead of winding through a tortuous channel.

The high velocities that impede upstream traffic about 30 per cent of the time, with the low-dam plan, would exist less than 3 per cent of the time in the high-dam pools. Dredging of silt accumulations that normally occur at the upper end of each pool, would be much less with the high-dam plan, due to lesser number of pools. The greater width and depth of the high-dam pools would aid in the maneuvering of large tows. Navigation and terminal difficulties attending moderate floods would be completely obviated by the high-dam plan.



Navigation Program for the Tennessee River

Note: This exhibit presents the low-dam navigation scheme, recommended by the U. S. Army Engineers in H. D. 328, 71st Congress, 2d Session, together with the high-dam scheme also recommended, in that document, as an alternative. The low-dam scheme was authorized by Congress in the River and Harbor Act of July 3, 1930, with the provision that high dams may be substituted for two or more of the low dams. The profile shows clearly the economy to navigation, in fewer lock-lifts and longer pools, provided by the high-dam plan. The map insert shows the navigation improvement on the lower part of each tributary, provided by backwater from the recommended high dams on the main stream.

low dams are the ones recommended in House Document 328 and authorized in the Rivers and Harbors Act of 1930, with the provision that high dams may be substituted for two or more of the low dams. The reservoir district of the high dams is shown in yellow. (Heavy shading in reproduction.) The scale of the chart is slightly exaggerated as to elevation for purposes of convenience. Aurora Dam will back up the water to a depth of 9 feet all the way to Pickwick Landing. The depth will vary from a minimum of 9 to a maximum of about 55 feet. Over most of the various pools the depths will be greater than in the low dam pools.

Following the surveys by the Army Engineers, Congress adopted a 9 foot channel on the Tennessee River in the Rivers and Harbors Act of 1930.

Aurora Dam, the one farthest down stream of the high dams, would extend slack water from the dam to the proposed Pickwick Dam Site. It would give a channel of 9 feet or better for the entire distance which is a little over 150 miles and for well over 100 miles, it would give considerably more than a 9 foot depth. Pickwick Dam would extend 9 foot slack water navigation to Florence, Alabama, would overcome the very serious rapids and bars in that section at Buck Island and Tuscumbia Bar, and would flood out the existing Riverton lock and Colbert Shoals Canal which are an impediment to large-scale navigation because of the small size of their facilities. The existing lock and dam No. 1 at Florence would continue in operation and would take navigation back to the Wilson Dam lock. The existing Wilson Dam pool extends 9 foot navigation to the proposed Wheeler Dam. Wheeler Dam would give 9 foot navigation to Guntersville, would overcome the serious rapids in that section and would flood out the old locks Nos. 1 and 2, and locks A and B

which are very small, and furnish only about a 3 foot depth in the canal. The Guntersville project, in the vicinity of Guntersville, would extend 9 foot navigation back to the existing Widow's Bar lock and dam, and it might be made high enough to flood out this lock and dam, and eliminate this small lock. Navigation could then continue directly to the existing Hale's Bar lock and dam. The crest there could probably be raised sufficiently to give a 9 foot depth to Chattanooga, to the proposed Chickamauga Dam, which is a little beyond Chattanooga. Chickamauga Dam Pool would carry navigation through a 9 foot channel over the existing rapids and shoals to the proposed White Creek Dam. White Creek Dam would extend the 9 foot level back to the proposed Coulter Shoals Dam and the Coulter Shoals pool would extend all the way to Knoxville, giving a channel 9 feet or better all the way, and flooding out the existing bars and rapids.

The low dam project would start about the same place as the proposed Aurora Dam. The first project would extend back 15 or 20 miles and the second about the same distance. A third dam and a fourth at Big Ben Shoals which would create a very short pool, would also be necessary, giving four short pools with four locks and dams instead of the one high dam. In the Pickwick Pool, there would be three low locks and dams, instead of the one at Pickwick. This would bring navigation back to the existing lock and dam No. 1 which, together with Wilson Dam and lock, would be used in either project. There would be four low dams in the area of the proposed Wheeler pool, and three in the proposed Guntersville pool which would bring navigation back to Widow's Bar. This lock and dam might, or might not, be used in the high dam project. The Widow's Dam pool extends back to the existing Hale's Bar lock and dam which would be used in

either case. In the proposed Chickamauga pool there would be five low locks and dams instead of the single one, and in the White Creek and Coulter Shoals pool, there would be six low dams each.

Each of the high dam locations referred to above was recommended by the Army Engineers as a feasible site. The high dam system would be a greater aid to navigation than the low dam system. The more important advantages are the saving in lockage time, saving in the cost of maintenance and operation of the locks and dams, and in dredging, and the saving in the first cost and annual charges on navigation improvements on the tributaries. The high dams will provide wider channels, wider pools, and more constant pool level. There would also be considerable elimination of high currents, less interruption by small or moderate floods and great increases in depth over practically the entire extent of the pool.

On the trip from Paducah to Knoxville, there would be a saving of about 11½ hours in lockage time due to the fact that a boat would go through only 10 or 11 locks in the high dam system and through 35 in the low dam system. There would be an additional saving of time in that a fleet could take a direct route through the larger pools and would not have to maneuver around and reduce speed for bars on either side of the channel.

The saving in maintenance and operation of the locks and dams would amount to about $1,065,000.00 annually. This is due to the fact that the navigable pass on the low dams is closed by a series of wickets. These wickets would be down part of the time and would have to be raised and it would take about $50,000.00 for annual operation and maintenance. On the high dams, the outside estimate would be $50,000.00 including the high lock and its proportionate share of the high dam operation and main-

tenance. I have not calculated in terms of money the saving in dredging cost, but there will be some difference there.

The high dam system will result in the following improvements on the tributaries: Aurora Dam will set slack water back on the Duck River for 12 miles and will take the place of two low locks and dams. Pickwick Dam would set back slack water 18 miles up Bear Creek and would take the place of three low lift locks and dams. If the proposed Tennessee-Tombigbee Canal is eventually constructed, this will result in a decided saving. In the Wheeler Dam pool, slack water would extend 28 miles up the Elk River, and take the place of three low lift locks and dams. The Guntersville pool will produce particular benefits on the tributaries, only if the proposed Warrior-Tennessee River Canal is constructed. In the Chickamauga pool, slack water would extend up the Hiawassee River and eliminate at least one low lift lock and dam. The proposed White Creek pool would eliminate two low lift locks and dams on the Clinch River and two on the Emory by extending slack water up these streams. The Coulter Shoals pool would eliminate one low dam on the Little River by extending slack water 14 miles up that river. None of these tributary dams are included in the 82 low dams in the low dam project.

There would be some benefit to navigation on account of the wider channels furnished by the high dams. A large fleet could take a direct route without the necessity of following the windings of the channel and being constantly on the watch for bars and obstructions, channel markings, etc. It could cut straight across the lake until it reached the other dam. Maneuvering and passing would be attended with less difficulty.

The high dam pools would have a nearly constant level.

This would effect a considerable saving in the first cost and operation of the terminals as they could be built to conform closely to the normal level of the pool instead of being built up in the air to provide for the great fluctuation which exists in the natural river and would exist in a low dam scheme. A large part of the first cost would be eliminated and it would not be necessary to adjust equipment for differences in the pool level.

There would be very little current in the high dam pools. The current would be perceptible only during large floods. In the low dam pools there would be a natural current for at least 30% of the time. During small and moderate floods, the navigable pass would be used in the low dam scheme. There would be some difficulty in going through these passes in maneuvering on the downstream trip and, in coming upstream, the tow would have to buck a very swift current. In the high dam pools moderate floods would produce very little current and would not impede progress. The greater depth in portions of the high dam pools would permit navigation with greater assurance and less output of power.

From the viewpoint of the improvement of navigation, Pickwick site would be the most logical of the downstream sites for the beginning of Tennessee Valley Authority operations, because from the mouth to Pickwick navigation is not extremely bad at present, but from Pickwick to Florence, the going is extremely difficult. There are a number of rock reefs, and with a four foot depth of water the high velocity makes it almost impossible to travel upstream with any kind of a tow, and the boats have to go through a canal which increases the difficulty. The Pickwick site eliminates all these difficulties, and therefore I consider it a very logical site for the improvement of navigation. Proceeding upstream, existing lock and dam

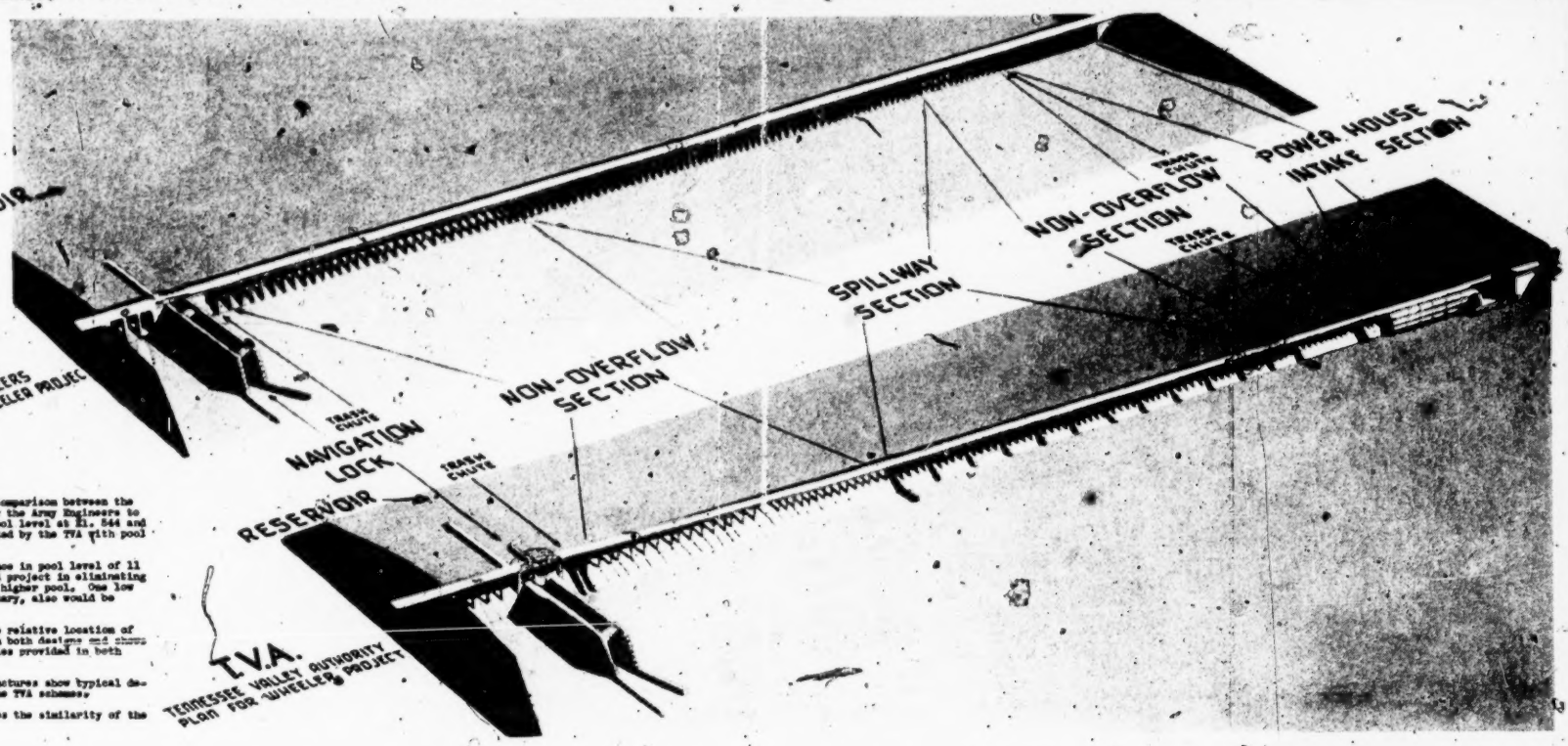
No. 1 and Wilson Dam take care of navigation adequately up to the head of Wilson Lake. There are then very serious difficulties which would be overcome by the proposed Wheeler Dam. This dam would extend slack water to Guntersville, an important trading territory, and also to Decatur, and therefore I would consider Wheeler site a logical one for navigation.

The Wheeler Dam project was given consideration at least as far back as 1914, as part of a general development around Muscle Shoals. In that year the Army Engineers made a survey that embraced both the Wilson Dam and Wheeler Dam locations and a House Document report was made on that subject in 1916. The two dams were linked together in all of the Army surveys and reports since about 1914. The Corps of Engineers had started construction of the lock before the Tennessee Valley Authority Act, and had planned to complete the lock and construct the dam. (The witness here identified a chart entitled "Comparison of Wheeler Projects proposed by U. S. Army Engineers and as being constructed by Tennessee Valley Authority. Basic data by C. T. Barker." The chart was introduced in evidence as Defense Exhibit #17, a reproduction of which appears upon the opposite page.)

The Army plan contemplated a short bulkhead section between the right bank and the lock, a lock 60x60 and a lift of 39 feet from the lower pool elevation of 505 to upper pool level of 544, a short non-over flow section, a spillway section, a second non-over flow section, a trash chute, a power house section with the power house intakes, and a stop log section to close up the gap for the time being. The Tennessee Valley Authority plans proposed a short bulkhead section on the right bank, practically the same as in the Army plan, the same lock because it was already

Defense Exhibit No. 17.

COMPARISON OF WHEELER PROJECT AS PROPOSED BY U.S. ARMY ENGINEERS AND AS BEING CONSTRUCTED BY T.V.A. - BASIC DATA BY C.T. BARKER



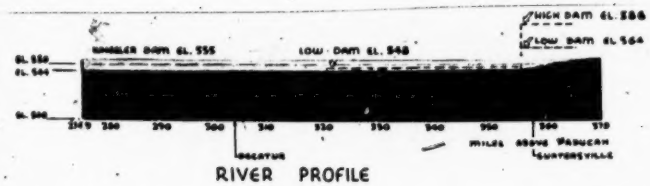
Note: This exhibit shows the comparison between the Wheeler Project as proposed by the Army Engineers to coincide with the lock with pool level at El. 544 and the project as being constructed by the TVA with pool level at El. 555.

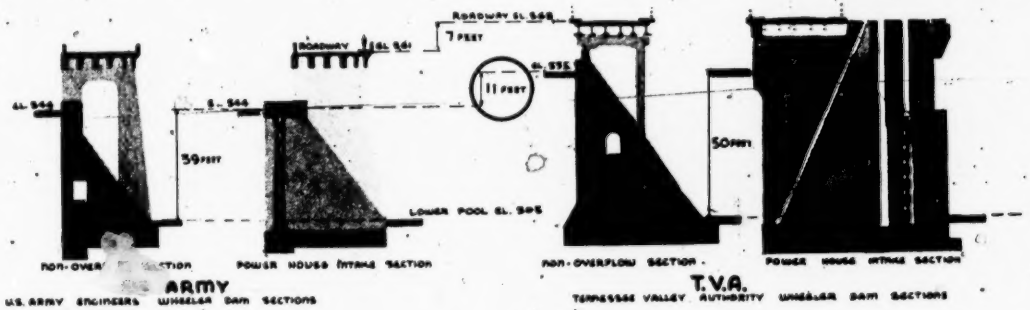
The profile shows the difference in pool level of 11 ft., and the effect of the TVA project in eliminating one low navigation dam by the higher pool. One low dam on the Elk River, a tributary, also would be eliminated.

The perspective views show the relative location of structures of various types in both designs and show the facilities for power facilities provided in both designs.

The cross sections of the structures show typical designs for both the Army and the TVA schemes.

The chart generally illustrates the similarity of the two designs.





constructed, a non-overflow section which is practically the same, a spillway section with gates about the same as the one in the Army plan, and a second non-overflow section about the same as the one in the Army plan. A power house section with intakes and a one unit installation of the Tennessee Valley Authority plan takes the place of the power house section with the stop logs and intakes in the Army plan.

The profile on the chart shows the improvement in navigation under the Tennessee Valley Authority plan in yellow and under the Army plan in green, (This is labelled on reproduction) The only material difference is the 11 feet in height in the normal pool level between 544 and 555. The Tennessee Valley Authority dam is 11 feet higher and would extend slack water to Guntersville which is an important town and railroad connection. The army plan would not have extended slack water quite that far because other improvements were contemplated to make up the difference.

The cross sections on the chart show the typical characteristics of the two designs. The only material difference is that the sections for the Tennessee Valley Authority dam are a little thicker because the dam is higher.

Wheeler Dam extends the navigable depth to Guntersville eliminating locks Nos. 1 and 2 and A and B and the cross-over between the two. The use of storage in the Wheeler pool would increase the low water flow in the natural river channel below Pickwick and will extend navigation farther up the Elk River. It will replace four low lift locks and dams instead of three on the main stream, and three instead of two on the Elk River.

The additional low dam which is eliminated by the addition of 11 feet of height to Wheeler Dam would cost somewhere around $2,200,000.00 if a large lock were installed.

The three dams on Elk River which would be made unnecessary by the Wheeler pool, would be worth about $3,000,000.00. The one that would be eliminated by the additional 11 feet would cost probably about $900,000.00

The principal improvement to navigation due to Pickwick Dam would be the removal of the obstructions to navigation immediately below Sheffield, particularly a rock cut through Tuscumbia Bar. It would flood out the old Riverton lock which is small, and the existing Colbert Shoals Canal which is narrow and only seven feet three inches in depth and would extend slack water to a depth of more than nine feet all the way back to Florence. It would also increase the depth between Pickwick and the mouth by the use of the storage in the pool.

The best location for power in the general vicinity of Pickwick Landing would be at Parker's Landing, 12 or 13 miles upstream. At that point the river is narrower and power could be produced more cheaply than at Pickwick. We selected the Pickwick site in order to connect up the navigation sequence from one pool to another, that is to say, Aurora Landing would extend a nine foot navigable depth to Pickwick Landing, but not to Parker's landing, so for this reason we selected Pickwick Landing. A conflict between power and navigation also arose in the selection of the location of the lock. The navigable channel is on the left bank which is also the best place for the power house. We decided in favor of navigation by putting the lock on the left bank and the power house on the right bank where it costs more money.

Wheeler and Pickwick Dams fit very well into the high dam program for obtaining a nine foot channel on the main river from Knoxville to Paducah. No other plans were proposed which would serve navigation as well as the high dam program.

The Corps of Engineers has discussed the plans and designs of the dams with the Authority and has approved these plans and designs from a navigation standpoint.

Norris Dam, which was then called the Cove Creek Dam, was considered in great detail in House Document 328. Following the completion of House Document 328, and just before the passage of the Tennessee Valley Authority Act, the Army made studies and actual surveys of the Norris Dam project. They were engaged on this at the time of the passage of the Tennessee Valley Authority Act and the surveys were continued for two or three months thereafter.

The highest point on the Army plans was the roadway at elevation 1066. The Tennessee Valley Authority plan calls for an elevation of 1055. There were no other substantial differences between the two plans except that the Army plan placed the spillway on the left bank of the stream. In the earlier studies the Army Engineers planned to install a barge lift, but this was omitted in the final plans, which were prepared as the result of actual surveys.

The release of stored waters from Norris Dam will increase the minimum channel depth from the mouth of the Clinch to Chattanooga in a low water year, such as 1925, about 2 feet. The controlling depth will be increased from one to three feet. In the middle section of the river, from just below Widow's Bar to just beyond Guntersville, where the controlling depths are now three feet, there would be an average increase of 2.2 feet. In the lower river, below the proposed Pickwick Dam, where the controlling depths are now about 4½ feet, the increase would be from 2½ to 2.6 feet giving a minimum of about 6½ feet. In a lowwater year like 1931, the increase in the river between the Clinch and Chattanooga would be about 1.8 feet, in the middle river below Widow's Bar, about 2.1

feet and in the lower river below Pickwick, 2.7 feet. These increases in depth are independent of the high dam program and are based on the present condition of the river.

These increases in depth would be of substantial benefit to existing traffic and facilities, and I am sure would attract additional traffic. The present limiting depth below Pickwick is 4½ feet and Norris Dam will produce a controlling depth of 6½ to 7 feet without further improvement.

At the present time, there is a fair amount of traffic between Wheeler and Widow's Bar. The traffic is not large, but there are a few important shippers there who would be glad to have an additional depth. The limiting depth in this section would be increased roughly from three to five feet. In the area between Chattanooga and the mouth of the Clinch there is practically no traffic at present except at isolated points where sand and gravel is being taken. The controlling depth due to Norris will be increased from one to three feet.

In the stretch from Paducah to Pickwick, a little over 200 miles, Norris Dam will give a channel of better than six feet, nearly seven feet, which would be a useful depth for navigation. In the Missouri River, the Army Engineers have spent about $70,000,000.00 to obtain a six foot project from Kansas City to the mouth.

Each of the dams now under construction taken as independent units will result in substantial benefits to navigation.

There will be some practical advantage in obtaining the three foot depth from Chattanooga to the mouth of the Clinch. At the present time, the middle section of the river between the head of Wilson Dam pool and Widow's Bar has only a three foot depth and it has been obtained

through considerable trouble and expense by the Corps of Engineers, so they must have thought that the three foot depth was valuable to navigation. The upper river would be at least comparable to that. Small barges and stern wheel towboats could be operated in that stretch. These vessels would probably not be different from those used in other parts of the river, but the difference would be principally in the loading. There have been some improvements by dredging in this section. The Army Engineers have done quite a little dredging and building of rock dykes and other open channel improvements between Chattanooga and Knoxville.

The pool provided by Norris Dam would be useful as a link in the ultimate plan for navigation on the Clinch River. It extends slack water 55 miles up the Powell River and 70 miles up the Clinch. It is a broad, long pool of great depth. The mileage figures just given are those existing at the normal stage of the river.

The Clinch River below Norris is navigable but with considerable difficulty. There would be no important commercial navigation on the lower Clinch until a canalized development is put into effect. If the lower Clinch were canalized, the reservoir area would form a useful link in continuous navigation, into the Tennessee River. The barge lift was not installed because it would be of no great use until the lower Clinch is canalized, and that development is probably considerably in the future and would be quite expensive. We considered the feasibility of installing a barge lift seriously and decided for this reason that it would not be a desirable or reasonable undertaking to expend the $3,000,000.00 necessary.

Coal is the principal product in the region north of Norris Dam. In view of the fact that practically all of

the potential traffic would be the downstream transportation of this commodity, it seems reasonable to put in a barge to barge transfer in the nature of a conveyor system to transfer the coal from the upper to the lower pool. We feel that this could be reasonably done and would be as satisfactory as a barge lift for handling coal or other similar commodities. It would take longer to get a ton of coal over the dam by the conveyor system than through a barge lift, but it would not be necessary to delay the floating equipment if storage facilities were provided on the downstream side. We are planning on furnishing such storage space. Both first cost and operating costs will be much cheaper with a conveyor system than with a barge lift.

In my opinion, each of the dams under construction and definitely projected is a necessary link in the plan for improving navigation on the Tennessee River and controlling the destructive waters in the Tennessee and Mississippi Valleys. Each of the dams is a practical and feasible project from a navigation standpoint.

Assuming the completion of the entire high dam system of seven dams on the main stream as outlined by the Corps of Engineers, I think the Tennessee River, when so improved, will be physically the best waterway in the United States. This opinion is based upon the studies made by the Corps of Engineers, particularly House Document 328. (Counsel then read into the record the following statement by Major General Lytle Brown from House Document 328: "The project should be definite and final, and it is possible to make it so in this case, if ever, because there has never been presented to Congress a more thorough and exhaustive study.").

Counsel then read into the record a statement of the Board of Engineers of rivers and harbors set forth in

House Document 328. The substance of this statement is as follows:

At the present time there are 69 terminals on the Tennessee River. The navigation equipment in service consists of 61 towing vessels and 180 to 183 barges owned by 39 operators. The 1926 commerce was 1,982,252 tons. The average haul was 19.6 miles, making a total ton-mileage of 39,020,096. Forty-eight per cent of this total is forest products, twenty-three per cent iron and steel, fifteen per cent sand and gravel, seven per cent farm products, and seven per cent miscellaneous freight. The commerce is small compared with potential traffic due to the fact that the river has not been adequately improved for navigation. An appreciable amount of traffic has developed between the mouth and Florence, but above Florence it is impracticable to use boats and tows of large capacity such as are necessary for the economic transportation of heavy freight, and navigation was suspended during the low water season. The estimated cost of transportation of the 1926 traffic by water and by rail is $842,777.00 and $2,720,481.00, respectively, making an annual saving of $1,877,704.00 on the water traffic.

Traffic on the tributaries is insignificant except for a considerable movement of sand and gravel on the lower four miles of the French Broad River.

As a result of an elaborate study, the district engineer found that in 1926, 9,559,000 tons of freight moved by rail which could have been transported more economically by water if a nine-foot waterway had been available to Knoxville. The saving in transportation cost would have been $12,231,000.00. For a waterway extending only to Chattanooga he estimates the movement of 3,982,000 tons with savings amounting to $5,111,000.00. Figures have

been reduced by forty per cent to make allowance for the fact that some of the traffic would move by rail in any event. This gives a saving of $3,060,000.00 for a waterway to Chattanooga and $7,3[illegible]0,000.00 for one to Knoxville.

On the basis of past traffic, the district engineer estimates that in 1950 the traffic actually using a longer waterway would be 17,800,000 tons with savings of $22,800,000.00 annually, while for the waterway extending only to Chattanooga, corresponding figures would be 7,400,000 tons and $9,600,000.00. He believes that actual traffic in 1950 would be greater than this because of the accelerated industrial development which would follow the completion of the waterway and the development of a large amount of electric power.

If I were instructed to improve navigation on the Tennessee and reduce the destructive flood waters in the Tennessee River basin, and by works on the Tennessee River reduce the destructive flood waters in the Mississippi River basin, I would build both high dams in the main river such as Wheeler and Pickwick and storage dams such as Norris.

Upon **Cross Examination** the Witness Testified as Follows:

I am hydraulic engineer in charge of the navigation planning section of Tennessee Valley Authority. I have submitted some recommendations through regular channels as to the adoption of plans on the projects now under way and proposed. My immediate superior is Mr. Bowman, and he, in turn, reports to Mr. Carl Bock. Mr. Bock is engineer in charge of the engineering planning division embracing all of the hydraulic features of the work.

I do not recall exactly when the construction of Pick-

wick was definitely determined upon, but it was quite a while ago. With reference to the present budget request and the mention of an additional dam on the main river and on one of the tributaries, I do not know whether there has been any definite allocation to any specific dams or location of the moneys there mentioned. I am not acquainted with the budget at all or with financial matters. I do not know what projects on the main river and what on the tributaries have been definitely planned.

I have made no study as to the potential power in the Clinch River below Norris Dam, but I presume that a power installation would be possible in this stretch of the river. I made no studies as to power except in a very incidental way.

From a navigation standpoint, the development of the lower Clinch River is a long way off. I know of no present plan for making it navigable to the foot of the dam. I have studied the improvement of navigation in this stretch only in a general way, to have that in mind as a broad picture.

White Creek Dam would not back up water to a navigable depth to the foot of Norris Dam.

I made no definite recommendations as to the order from the standpoint of navigation in which these dams should be undertaken, but I expressed a good many opinions approving of what we are doing. I have given a number of reports stating in general what, in my opinion, was the order in which dams would best subserve the purpose of navigation, and I submitted a number of memoranda along this line and reports along with the general engineering studies. I have not submitted complete reports on this matter, but memoranda setting forth the engineering and navigation features of the dams under con-

sideration. I do not have these reports here available. I didn't make a report showing the order all the way up and down the stream, but simply miscellaneous memoranda.

In the ultimate development there will probably be a much larger tonnage on the river north of Chattanooga. I have reported on the development of the stretch between Chattanooga and Knoxville and written memoranda considering it not feasible as an immediate project. However, dams could be constructed in this stretch. There is no immediate project for the improvement of this portion of the river. I do not know what other dams are within the budget projects of the Tennessee Valley Authority.

I came with the Authority in November, 1933, and started making studies and partial reports very soon thereafter.

While House Document 328 was being compiled, I was in the Chattanooga office with the Corps of Engineers working on hydraulics and hydrographic studies in connection with practically all phases of that report. A large part of the study was devoted to the river flow and the water stages and data of that character but this was not all of the study.

I have had experience in connection with the actual operation of navigation. I was in charge of the U. S. Engineers Office at Sioux City, Iowa, in charge of construction of navigation improvements on the Missouri River at Sioux City and Omaha. My duties included both construction and operation on the river. I was also at one time in the U. S. Engineers Office at Wilson Dam. I had to do with improvement of navigation, operation of locks, construction of dykes and dredging the channel from Riverton to Hale's Bar.

The figures as to tonnage which I gave on direct examina-

were taken from the annual report of the Chief of gineers. I believe they included the tonnage which used in the construction of Wilson Dam. Pig-iron is no ger produced in this area. I do not recall the propor- of pig-iron in the 1926 tonnage figures which I used, I believe it was about the same as sand and gravel and than the other items.

he navigable depth of the Tennessee at its confluence n the Ohio is nine feet. The controlling depth on the o and Monongahela is also nine feet. The improvements these rivers are by means of low dams. Due to the uliar industrial conditions the Monongahela River prob- y has the highest river tonnage in the United States. f the Tennessee River is improved by a series of high ns, it will be physically the best improved waterway he United States. The Hudson River and the Great es are not in this classification.

do not know whether Tennessee Valley Authority plans template the completion of navigation in the near fu- e. My statement that it would be the best improved erway was based on the hypothesis that navigation uld be completed by a series of high dams. If the high n program is not completed, navigation conditions will poor above Chattanooga and fair between Pickwick and mouth. The same type of vessel could be used between kwick and the mouth that is used on the Mississippi and o Rivers, but it will be necessary to load the equipment ttle lighter. A different motive power would not be essary but the lower depth would require a greater out- of power with a given load.

ickwick Dam would give nine foot navigation to the er edge of the pool. The Wheeler pool would give nine t navigation to Guntersville. We would then have nine

feet from Pickwick to Guntersville and less than nine feet below Pickwick.

The very largest towboats draw 4½ feet or maybe more. The principal operation on the river, but not necessarily the most important, would be the transportation of very heavy and bulky material such as sand and stone.

I have my work sheets available to show the items considered in arriving at the figures of $1,065,000.00 saving in the annual operation and maintenance charges with the high dams. I did not take into consideration cost, depreciation, interest on investment or additional flowage rights, but simply the operating and maintenance charges exclusive of fixed cost on the investment. No depreciation was included, but I did include all major repairs and dredging necessary to keep the project up to its original degree of efficiency. Some dredging would probably be necessary, but I think the low dam project would require considerably more dredging.

I did not include in my figures the difference in power requirement for the operation of locks under the high dam and under the low dam system. This is not a large amount and the locks could be acctuated with a rather small installation. There is a 700 KW unit at Wilson separate and distinct from the commercial units. The cost of such a unit is relatively small.

My estimate as to the saving in operation with high dams did not take into consideration the difference in first cost between the estimates in House Document 328 of $75,000,000.00 and $192,000,000.00.

The barge lift was omitted in the construction of Norris Dam because it seemed unreasonable to expend the funds necessary for that purpose.

I made no recommendations to the Authority either as

to emplacements or as to the hydro electric installations in the high dams. I gave no consideration to this problem and initiated no suggestions. I considered it was my duty to speak and recommend with reference to any factor relating to navigation.

The design of Wheeler Dam as planned by the Corps of Engineers is not shown in their published documents. They were actually building a lock and they designed a dam to accompany that lock. They had rather a definite plan as to the construction of the dam. It was more than a project study.

In Wheeler Dam as designed by Tennessee Valley Authority the emplacements and intakes were put in and one power unit was contemplated. The Army design included the power intakes and a log section blocking that off until further action was taken regarding power. Substantially they provided only for the intake and the rest of it was "just plain dam."

There is somewhat less head at the Parker Landing site than at Pickwick, but the difference is not very great. The site selected gives a somewhat higher head at a greater cost. The higher head gives more potential power.

In computing the saving of time in the high dam system, I did not allow for the saving in time by use of the navigable pass on the low dam during intermediate and high water because purely on the upstream traffic that would cause them to lose a lot of time.

Sixty to one hundred years ago a great deal of the river traffic moved downstream and the barges were destroyed at the end of the trip but this is no longer customary. In some cases barges still go down loaded and come back empty.

I worked on the estimates of tonnage and prospective tonnage which are reflected in House Document 328. I do

not now disclaim the accuracy of the recommendations and conclusions contained in that report.

Slack water from White Creek Dam would extend up the Clinch River probably half the distance to Norris. It would not extend six foot navigation to the foot of the dam. The upper pool elevation of White Creek Dam is shown in House Document 328 as 740 feet.

The hypotheses which I have made with the exception of the changes in elevation at Wheeler and Pickwick are based upon House Document 328 and I have taken the projected elevations of the high dams and the low dams as given in that document.

The plans for navigation through Norris Dam had not reached the point of any final and definite study and recommendation. The governing consideration was that the movement of tonnage through the dam was so far in the future that is was not necessary to make provision for it at the present time. Navigation through the dam has been considered in the design of the dam as an ultimate proposition. We know what we can do when the time comes. Representatives of Tennessee Valley Authority have been going around this district during the last few days to ascertain about the question of coal conveyors.

I, personally, have been considering some navigation alternatives at Norris Dam for a long time. I have had no personal experience with the operation of coal conveyors in relation to dams. I have been making studies on the problem of navigation through Norris Dam, but I have made no definite reports. I discussed the question with my superiors quite often, but I do not recall any definite instructions as to the preparation of a study on this question. During the past three weeks I have made a preliminary analysis of the conveyor system at Norris Dam and have gotten together a few figures.

I am not familiar with daily fluctuations in the Norris pool from the manipulation of power. What I have said with reference to the effect of Norris Dam upon navigation would depend to some extent on what use is made of it at the time from the point of view of power and flood control.

Under present plans the Corps of Engineers is in charge of the operation of locks on the main river. As matters now stand I assume that Tennessee Valley Authority will have the operation of Norris Dam and pool level, but I don't know that any plan has been definitely determined.

Norris Dam was designed by the Reclamation Service and not by the Corps of Engineers.

With reference to Exhibit No. 16 the horizontal scale in miles is definitely shown. I don't know that any exact scale was used in making the chart. It was intended as a graphical illustration and the figures showed the exact distance. It shows the low dam projects flooded out by the high dam projects exactly as they would be and in the proper relation.

I do not know whether the extra 11 feet in height has been accomplished at Wheeler Dam by extra height of gates or spillway. The normal pool level under the Tennessee Valley Authority plan is 11 feet higher than under the design of the Army Engineers. That will result in more potential power.

I do not know of any definite plans for navigation in the Norris pool in the case of a full draw down. I know what was projected in House Document 328.

The Witness Testified upon **Re-Direct Examination** as Follows:

Just before the Tennessee Valley Authority Act was

passed the Army was making final surveys for a dam at the exact site where Norris Dam is being constructed. The Tennessee Valley Authority has used the plans of the Bureau of Reclamation which are slightly different from the Army plans. The Bureau of Reclamation has a number of such projects in other sections of the country for general river development including hydro-electric projects.

The Army had started construction at Wheeler Dam before the Authority began operation.

I participated in the conference leading to the choice of the site of Pickwick. The site now being developed is the one which I recommended for navigation purposes. By building first, the projects now under construction, we accomplished considerably more for navigation by developing the bad stretches first than if we had gone to other portions of the river. This was the principle upon which we operated.

Low dams have no utility for flood control purposes.

Counsel for the defendants at this point read from the Annual Report of the Chief of Engineers for the year 1933 beginning at page 749 under the general heading "Improvement of Tennessee River. Previous projects adopted by Congress for the improvement of the Tennessee River." The substance of this excerpt is as follows:

The total cost for all previous projects on the Tennessee River was $15,123,218.73.

The project adopted by the Rivers and Harbors Act of 1930 provides for a nine foot minimum channel from the mouth to Knoxville 647.7 miles, to be obtained by the construction of low dams, provided that under the provisions of the Federal Water Power Act a high dam with locks may be substituted for two or more of the low dams and built by private interests, states or municipalities. If the

high dams are built before the low dams, the United States shall contribute to the cost of substituted structures an amount equal to the estimated cost of the navigaion works for which subsitution is made. The Chief of Engineers was directed to report to Congress on the prospective cooperation offered by responsible interests in the construction of high dams.

The project includes 32 low dams in addition to those already built.

The extreme fluctuation in the stage of the river varies from about 49 feet to 55 feet below Riverton; from 30 feet to 50.4 feet from Riverton to Colbert Shoals; from 30 feet to 33 feet between Colbert Shoals and Florence; from 11 feet to 33 feet between Florence and Brown's Island; from 11 feet to 49 feet between Brown's Island and Hale's Bar; from 16 feet to 53 feet between Hale's Bar and Chattanooga, and from 36 feet to 53 feet above Chattanooga. The estimated cost for new construction is $73,709,000.00 and $40,000.00 annually for the maintenance and operation of each lock and dam. This project was adopted in the Rivers and Harbors Act of 1930, which authorized the appropriation of Five Million Dollars for the prosecution of work on the project. On December 7, 1931, a report was transmitted to Congress on the prospective cooperation of responsible interests and also recommended that $22,500,000.00 be appropriated for the construction of low navigation dams to provide nine foot navigation from Colbert Shoals to Hale's Bar.

House Document 652, 66th Congress, 2nd Session, contains a complete report of terminals on the Tennessee River. Municipally owned terminals have been constructed at Chattanooga; other public terminals are mostly unimproved landings. Existing commerce is at a great disadvantage due to the lack of suitable wharves.

Above Chattanooga the channel was maintained during the year 1932 by dredging, dyke construction and the removal of surface obstructions. $40,724.45 was spent on dredging. $11,600.67 was spent on dyke construction at Muscle Shoals and $68,062.16 on dyke repairs at Bogart Shoals and Pickle Island. $4786.63 was spent in maintaining channel markers. This work was all done with Government plant and hired labor. The total cost for maintenance was $63,974.11.

From Chattanooga to Riverton the existing channel was maintained by dredging and dyke construction between Hale's Bar and Florence Bridge. The cost of dredging was $43,243.73. The dyke was constructed below Fellfonte Bar at a cost of $8677.01; dykes were repaired at a cost of $10,857.33. Searching the channel for boulders and the removal of a rock ledge cost $301.79, and $868.04 respectively. Channel markers were maintained at a cost of $3528.54.

A contract is now in force for the construction of a lock at the General Joe Wheeler Dam site. The total contract price is $1,158,711.45; $131,870.50 has been paid to the contractor. The cost of the work in connection with the construction of the lock is $292,462,071.00, the total cost for this section was $360,324.09, of which $67,862.02 was for maintenance. Total cost of the section above Riverton was $424,298.20, of which $292,462.07 was for new work and $131,836.13 for maintenance; total expenditures were $468,479.41.

Below Riverton $76,060.34 was spent on dredging, $8675.40 on construction of a dyke, $749.35 on the installation of channel markers, $3859.61 on miscellaneous channel investigations, or a total of $89,345.10. Total expenditures were $83,601.00.

Counsel now read from House Document 328 at page 2, in substance as follows:

Floods occur frequently. The damage done by ordinary floods is not great but the flood of 1926 caused damages estimated at $2,656,000.00. Still larger floods are possible and the flood which might occur once in five hundred years would do damage amounting to $14,000,000.00. The average damage from floods is about $1,780,000.00 annually. The only place where large damages are concentrated in a limited area is at Chattanooga.

Only twenty per cent of the available power which may be economically developed at the Government hydro-electric plant at Muscle Shoals has been developed and the rest has gone to waste. The reason for this is that no decision has been made as to the final disposition of the power and nitrate plants and no long term contracts could be made. If the installations at this plant were increased to 340,000 kilowatts, it could produce about 2,000,000 KWH of primary and secondary power in an average year without further development.

Including all proper charges for interest, depreciation, amortization, maintenance and operation but no taxes or insurance, electricity can be produced at a cost of 1.36 mills per KWH. This power could be transmitted in conjunction with the existing steam plants for use within a radius of 350 miles to give firm power at a cost of 4.16 mills per KWH if it could be sold. This is less than the cost at modern steam plants. The power could be developed more economically with the aid of Cove Creek storage, but this storage is not essential. In order to develop the power it will be necessary to increase the installation and secure authority to enter into long term contracts for the sale of power.

Most of the flood damage occurs on the main stream and the lower parts of tributaries which are over-flowed by backwaters. In 1926 floods caused an estimated damage of $2,650,000.00. Larger floods may some day occur and the damage from the super-flood would amount to $14,353,000.00. The average annual damage is $1,780,000.00, if due weight is given to the possibility of future floods, greater than those previously recorded. On the tributaries large floods may occur at any time. On the main stream all larger floods of record have occurred between December and April.

GENERAL GEORGE B. PILLSBURY,

called as a witness on behalf of the defendants testified upon **Direct Examination** as follows:

I am Assistant Chief of Engineers of the United States Army. I graduated from the United States Military Academy in 1900. Since that time, except for four years when I was Assistant Professor of Mathematics at the Military Academy and for two years when I was attending various military schools, I have been engaged in the practice of civil and military engineering. I was successively Chief Engineer of the Alaska Road Commission, District Engineer in Charge of River and Harbor Work and Fortification Construction at New London, Connecticut, and at Los Angeles, California, and then a member of the Joint Board of Engineers on the St. Lawrence Waterway, in charge at the same time of the United States Lakes Survey on the Great Lakes, District Engineer at Philadelphia, and Chief of Engineers. For three years prior to my present appointment I was Assistant to the Officer in Charge of River and Harbor Construction throughout the United States, and I have gen-

eral supervision of all river and harbor work undertaken by the Department.

I am acquainted with the navigation problem on the Tennessee River. I was a member of the Board of Engineers for Rivers and Harbors when the project was before that Board for consideration.

The Engineering Department cooperated with the Tennessee Valley Authority in the design of the navigation features of Wheeler and Pickwick Dams, and those designs are in our opinion satisfactory for the purpose of navigation.

In adopting the project for the improvement of the Tennessee River, Congress directed that the Department should submit a report of the cooperation offered; looking toward the construction of high dams instead of low dams. Such a report was submitted and is printed in House Document No. 131, 72nd Congress First Session. This report recommended that funds be made available immediately for the construction of low navigation dams from the head of Colbert Shoals Canal to Hale's Bar Dam. We thereupon directed the District Engineer in charge of that improvement to recommend the particular dams that should be undertaken with the $5,000,000 which Congress had authorized. He recommended and we approved the recommendation that the first dam undertaken be at the Joe Wheeler site, as that will afford the greatest benefit to navigation for the expenditure.

At the time that the Tennessee Valley Authority took over the Joe Wheeler Dam we were constructing a lock which was the first step in the construction of a lock and dam to replace the low dam recommended at that site in the project document. The construction also of the lock of the Elk River Canal which was included in the original

plan would be superseded and also the next low navigation dam upstream.

Mr. Barker's discussion of the Army plan for the dam was substantially correct. (At this point the witness identified a document entitled "Engineering News Record, September 6, 1934," identified the letter contained therein as having been written by him and stated that it accurately stated the facts regarding the position of the Engineering Department as to the barge lift at Norris Dam. This document was introduced in evidence as Defense Exhibit No. 20, a reproduction of which appears upon the opposite page).

There is no question as to the superiority of high dams over low dams for purposes of navigation. They are superior in that they reduce the time lost by vessels and tows in lockage. The time required to pass through a lock depends on a variety of circumstances. The vessel or tow must check speed and stop. If the level of the water in the lock is not the same as the level in which the vessel or tow is approaching, these levels must be equalized. The vessel or tow then enters the lock. The lockmaster must see that it is safely secured and that the gates are clear. He then closes the gates and opens the valves in order that the water may adjust itself to the next pool. The time required varies with the skill of the workmen and the circumstances in the case, but the average time required to pass through a low lift lock is about 26 minutes. The actual filling of a lock is ordinarily at the rate of about three feet a minute. For a 30 foot additional lift the increased time would, therefore, be 10 minutes, making a total of 36 minutes to pass through high lift lock. Based on these figures, the additional lockage time required with low dams on a trip from Paducah to Knoxville would be nine hours and 20 minutes.

Defense Exhibit No. 20.

The Barge Lift at Norris Dam

Sir—I desire to correct a misapprehension with respect to the plans of this department for a barge lift in the Norris Dam, which is referred to in an article on the design of that dam published in *ENR*, July 12, 1934, p. 44.

The comprehensive report on the Tennessee River, published in House Document No. 328, 71st Congress, 2d session, presented in accordance with the provisions of the law directing the survey the ultimate use that may be made of the waters of the Tennessee Basin by the United States and its citizens. It contained plans for the maximum development of the river and its tributaries for navigation, power production and flood control. The total estimated cost of all these works was in excess of one billion dollars. In presenting this report the Chief of Engineers pointed out that this sum is not to be confused with the cost of any project to be executed at the expense of the United States government. This plan for eventual development included a barge lift at the Norris Dam and at all similar higher reservoir dams on which possible eventual demand for navigation could be foreseen. The construction of such barge lifts, however, was never recommended by any official of the Engineer Department, and at no time received serious consideration in the plans of the department looking toward the construction of the dam.

It cannot, therefore, be correctly stated that the present plans for the dam provide for the elimination of the barge lift, since this barge lift never had a place in the design of the dam except as a distant possibility in the indefinite future.

G. B. PILLSBURY,
Brigadier General
Acting Chief of Engineers.

Washington, D. C.
Aug. 24, 1934

THE ECONOMIES referred to in the article in question were those made possible by the entire elimination of the barge lift, even as something to be considered as a distant possibility. As General Pillsbury states, no estimate of the cost of navigation facilities was included in the army engineers' report, but the design for the dam at Cove Creek (Norris Dam) included in that report (See *ENR*, May 11, 1933, p. 583) made provision for the possible future construction of a barge lift, not because the army engineers recommended it but because they were under instructions to consider the possibility of making the stream navigable. Of necessity, the lift had to be located near the center of the dam where it was accessible from the channel below. So located, it became the controlling factor in the location of the spillway and the power house. Unhampered by any such limiting factors, the engineers of the TVA have been able to produce a design which they believe can be built much more economically than a dam that has to provide for future navigation facilities.
—EDITOR.

The second advantage of high dams is the saving in the cost of operation. In the Ohio River, locks having considerable traffic cost about $50,000 per year and the cost is about the same for the low lift movable dam and for the high lift lock. The seven high dams would, therefore, give an annual saving of over $1,000,000 in the cost of operation.

Dredging is usually necessary to maintain the channel at the head of the various pools. Much less dredging is required where there are seven pools than would be required with 32.

Boats passing through the open waters of a deep pool can proceed with greater speed and with less power and fuel consumption for the attainment of that speed than they can in narrow channels. In the lower and deeper portions of the pool they can proceed in a straight line.

Small floods do not interrupt traffic either with low or high dams, but with low dams the strong upstream current during small floods retards the movement of the vessel. With a high dam the water is practically slack in the deep portion of the pool. However, the disadvantage to upstream tows would be in large measure or wholly counterbalanced by the advantage to downstream tows.

The river stages to be anticipated from high dams would make the cost of terminal construction and maintenance materially less than is required when handling devices must be designed to operate through a wide range of river stage. The high dam system would also materially contribute to the navigability of tributaries.

There are two types of movable dams: the so-called wicket type, with a navigable pass in which the dam is manipulated to lay flat on the river bottom during high water; the other is the so-called gate type, in which a

series of piers are built across the river and gates between those piers are raised in order to allow flood water to pass and to prevent upstream overflow. The wicket type is difficult to operate and requires special skill and good management to prevent serious delays when the dam is being raised, as it cannot be raised until the river at the side has fallen materially below the pool level. The gate type of dam does not have these disadvantages, but as the gates must be raised above flood level instead of being lowered, high piers and necessary if the river is subject to a wide flood fluctuation, and the gate type dam is much more expensive than the wicket type. Its installation was not contemplated in the plans presented in House Document No. 328. If this type of dam were substituted, there would be a substantial added expense.

Movable dams were installed on the Ohio primarily for the reason that when their construction was first undertaken, about 50 years ago, the most important movement on the Ohio was that of great tows of coal barges which were assembled near Pittsburgh and moved down the river during high water. Those concerned in this commerce objected strenuously to the construction of any type of dam which would require the breaking up of these tows, and therefore construction was begun with the wicket dams, which could be laid flat on the river bed during high water so as to afford no obstruction to the movement of these tows. The barges now in use on the Mississippi and Ohio are of the permanent type and intended for continuous service. On the Mississippi there is considerable upstream movement of commodities, and also on the Ohio, as far at least as Cincinnati.

On the Monongahela there are fixed dams which are usually fairly low in height. The height of these dams

was restricted to prevent the overflow of the extremely valuable land on either side of the river. The cost of flowage rights is usually the determining factor and it is desirable that dams should be built as high as possible because the higher the dams the fewer there are of them. In the Warrior River we have below Birmingport a dam 61 feet in height, which is higher than most of the dams contemplated on the Tennessee. This is wholly a navigation dam.

The low dams have been replaced by high dams on the Ohio River. After the great tows of coal were discontinued and industries established on the River below Pittsburgh, the maintenance of the constant pool level at low water became a matter of great importance and Congress authorized the replacement of the movable dams with fixed dams. Three upstream dams were replaced with two fixed dams at a cost of $6,590,758. We are now building a third gate dam with a lift of 19.4 feet at a cost of about $6,000,000 which will replace two more, and we have just let a contract for the construction of a dam with a lift of about 26 feet below the mouth of the Kanawha River as well as the replacing of three dams on the Ohio. The Kanawha River project was begun in 1928 and provides for six foot navigation by means of ten low locks and dams, some of which were movable and some fixed. We have recently replaced the four upper dams with two dams of the gate type with lifts of 24 and 26 feet respectively at a cost of $6,654,700, and we are planning to replace the remaining six by means of the high dam in the Ohio River which I have just described and another dam of about 26 feet lift in the lower portions of the Kanawha. These will afford on the Kanawha River, which is an important coal tributary of the Ohio, a reliable depth of nine feet, corresponding to the depth in the Ohio.

As the movable dam creates little obstruction to the river flow during the floods, it may be, and if necessary is, founded on sand. A fixed dam, whether high or law, must have a suitable foundation, and it is not good engineering practice to found a high dam on anything but rock if it is to be an overflow dam as a river dam must be.

If high dams are subsequently constructed, low navigation dams are submerged and are no longer useful. The cost of removal, however, is not a serious factor.

Upon **Cross-Examination** the Witness Testified as Follows:

To refer to the recommendations of the Corps of Engineers in House Document No. 328 is not accurate. The District Engineer, Division Engineer, Board of Engineers for Rivers and Harbors, and the Chief of Engineers all reported, as shown in that document, somewhat different recommendations. The guiding recommendation is that of the Chief of Engineers for the construction of low dams, with the provision that if high dams were first constructed, the estimated cost of the low dams replaced would be credited to the high dams.

In all the considerations of the project by the Department, it was recognized that high dams are preferable but much more expensive. They are much more expensive and somewhat in the relation set out in the estimates contained in the report. These estimates form a fair basis for consideration.

In estimating the difference in the cost of operating high dams and low dams, I considered only annual operation without reference to depreciation or first cost, except depreciation on working parts.

The Tennessee Valley Authority has not conferred with

the Chief of Engineers as to the manner of the construction of the dams, the types of hydro-electric installations, and as to whether or not units should be installed. In the proposed Pickwick Dam the design of the lock was actually made by our District Engineer. I do not know whether the War Department will operate the locks. That rests with Congress. Up until last year a permanent appropriation had been made by Congress for the operation of locks and other navigation features. These appropriations were rescinded in the last Congress and no new authorization has been made as yet.

The Chief of Engineers has had nothing to do with the design of these dams in relation to hydro-electric installation, but we have instructed our Chief Engineer in Nashville to cooperate fully with the Tennessee Valley Authority in all matters where cooperation was requested, and he has done so. We have made available to the Tennessee Valley Authority such information as the War Department has accumulated.

The Clinch River up to the site of Cove Creek is listed as a navigable river by the War Department. This merely is the expression of the view point of the Department as concerns the administration of the laws for the protection and preservation of navigable rivers.

The studies of the Corps of Engineers indicate that there is large and heavy potential tonnage up the Clinch River. I do not know the amount of potential traffic relative to that on the other tributaries of the Tennessee, but I do know that the Clinch River penetrates into the coal region. The construction of Cove Creek Dam does not block off the Clinch River for improvement for navigation. I have not been conferred with by the Tennessee Valley Authority with reference to the plans for navigation through

the Clinch River, and I am not familiar with its plans, but I have been conferred with as to Wheeler and Pickwick.

Before the Tennessee Valley Authority was created we had begun the construction of the lock at Wheeler Dam. After it was created and after they decided to construct the dam, we revised the plans of the lock to conform to the design of the dam which they had chosen. I think the dam was designed by the Tennessee Valley Authority. I don't know who designed Pickwick Dam. The Corps of Engineers did not design it. We designed the lock which was adapted to the design of the dam. We did not design the emplacements for hydro-electric units, nor were we invited to give advice or suggestions with relation thereto.

I am acquainted with Colonel Tyler, who is Division Engineer of the Lakes Division with general supervision of all river and habor construction on the Great Lakes and their navigable tributaries. He is a man of high professional competence.

The funds used in the construction of the lock were not the $5,000,000 authorized under the Rivers and Harbors Act of 1930, but were those appropriated in 1932 for the emergency relief of the unemployed. A lump sum was appropriated at that time for the construction of river and harbor works and a portion of that sum was allocated to the construction of this lock. I do not recall the date on which construction was begun.

I do not dissent from the conclusions submitted to Congress in House Document 328 and approved by the Rivers and Harbors Act of 1930, but the intent of those recommendations was that it would be better to improve the Tennessee River by high dams rather than low dams, but that the construction of low dams was at that time the most feasible means of securing a satisfactory navigation im-

provement. By feasibility I mean in the sense that due regard were given to expenditures. It has always been the view of the Department that the desirable improvement was with high dams, the excess cost being paid by the return from the surplus power. The reports were not in any sense misleading as to their recommendations. They clearly show their intent on their face. My testimony is not intended to be contradictory to the reports reflected there under the basic conclusion on which they were based.

GEORGE R. CLEMENS

Called as a Witness on Behalf of the Defendants Testified upon **Direct Examination** as Follows:

I am senior engineer with the Mississippi River Commission. I graduated from the University of Michigan in 1921 with a degree of Master of Science in Civil Engineering, having specialized in hydraulics. In 1933 I received a graduate degree of civil engineer from the University of Michigan on the thesis "Reservoir as a Flood Control Structure." This thesis was later published in the proceedings of the American Society of Civil Engineers in May, 1934. I am an associate member of this society and a registered engineer in the State of Michigan. From 1919 to 1925 I had a varied engineering experience and for a while I was an instructor in surveying and other civil engineering studies at what is now Wayneburg University, but was then called the College of the City of Detroit. In 1925 I became associated with the Department of Engineers of the United States Government and during the last ten years have been engaged in various assignments within the Department.

My first assignment was as civilian assistant to the Board of Army Engineers, studying a waterway from the

Great Lakes to the Hudson River. I was attached to the Buffalo district. I subsequently was engaged in the study of the development of the St. Lawrence waterway and the regulation of levels of the Great Lakes. During this time, I was attached to the lake survey office in Detroit. General Pillsbury was the district officer. In 1927 I went to Washington as civilian assistant to the Board of Engineers for Rivers and Harbors. I was detailed to various studies in connection with the preparation of the flood control project on the Mississippi River in 1927 and 1928. During this assignment I prepared a number of studies for the reservoir board and drafts of portions of their reports.

When the Mississippi Flood Control Act was adopted, May 15, 1928, I was transferred to Vicksburg, Mississippi, as Civil Assistant to the District Engineer, specifically in charge of the 308 studies in the Vicksburg district under the supervision of the district engineer on the Red, Ouachita, and Yazoo Rivers. In 1931 I was transferred to the staff of the Mississippi River Commission at Vicksburg. I have charge of the preparation of the comprehensive reservoir report on the Mississippi River and its tributaries, and I am designated as civilian in charge of the general hydraulic study section on the dredge operations on the Mississippi River. The Mississippi River Commission has been in existence since 1879 and is charged with navigation and flood control improvement on the Mississippi River. Its members are General Harley B. Ferguson, President, Colonel Ernest Graves, Colonel George R. Spaulding, L. O. Colbert of the Coast and Geodetic Survey and Edward Fladd of St. Louis. There are two vacancies.

The Commission is charged with carrying out navigation and flood control work on the Mississippi River under the general direction of the Chief of Engineers. Until

1928, the Commission was a separate body reporting to the Secretary of War. By the Act of May 15, 1928, it was placed under the general direction of the Chief of Engineers. The Commission is engaged in progressive development of works on the Mississippi River. It started the levee system in 1882 and has designated various levee grades from time to time.

My work has embraced control of the Mississippi River waters, the levee system, flood waters, plans for reservoirs, etc. (The witness here identified a chart entitled "Alluvial Valley of the Mississippi River" which was introduced in evidence as Defense Exhibit No. 21 which is omitted from this narrative.)

This chart is an accurate portrayal of the Mississippi River, the levee system and other related projects. It shows the lower portion of the Mississippi River from Cairo to the Gulf and it shows the overflow area, the general location of the levee system and the general plan as adopted by the Act of May 15, 1928.

The main tributaries of the Mississippi are the Upper Mississippi above the Missouri, the Missouri, the Ohio, the Tennessee, and the Cumberland, the St. Francis, the White, the Arkansas, the Yazoo, the Red and the Ouachita.

The three main sections of the Mississippi are the upper section above St. Louis, the middle section between St. Louis and Cairo, and the lower Mississippi below Cairo. Cairo is at the junction of the Ohio and the Mississippi River and is about 45 river miles below the mouth of the Tennessee.

The most serious flood problem is on the lower Mississippi between Cairo and the Gulf. In 1927, there occurred in this area the most destructive and in some ways, the greatest flood of record. A number of breaks occurred in the then existing levee system resulting in the overflow

of about 23,000 square miles. Approximately 200 lives were lost and property damage ran into many millions of dollars.

Following this flood, the Chief of Engineers made a very comprehensive study of the entire problem and considered many different ways to control the floods. He appointed a number of boards which, during the summer and fall of 1927, considered different possibilities including levees, reservoirs and diversions. On the basis of all of these, the Chief of Engineers, in the fall of 1928, prepared a project for the Mississippi River which he submitted to Congress as his recommendation for the best plan of control. At the same time, another plan was submitted by the Mississippi River Commission.

At this time a plan was studied which considered control by means of a series of reservoirs located on all of the tributaries. It was a very comprehensive system involving over 200 reservoirs on the Tennessee, Cumberland, Ohio, and all the other tributaries that I mentioned. In my studies I have considered the Tennessee as one of the main tributaries. It enters the Ohio so close to the mouth that it is frequently so considered.

The studies in 1927 were general and were of an emergency nature and not entirely conclusive. The Act passed in 1928 directed the extension of these studies and the making of further studies which have subsequently been made.

There are three methods of controlling flood waters. The first is by a series of levees or dykes along the main stream. The second plan would be to have supplementary channels. We might confine a portion of the flood waters by the levee system and divert part of it through supplemental channels. The third system would be control by the retention of flood waters in the tributaries.

The function of high dams on the tributaries would be

to accomplish the third general method of control—that of holding out portions of the flood waters and thereby reducing the height of the flood throughout the lower section of the valley. Since 1927 a much more comprehensive and complete study has been made as to the desirability of such a system, and the Mississippi River Commission has recently submitted a report on tributary reservoirs to the Chief of Engineers. This report is considered confidential because it has not been transmitted to Congress.

A study was made of a comprehensive system of reservoirs to determine how much lowering can be accomplished at Cairo and other key points along the Mississippi River in flood times. We find that in the case of the so-called super-flood, the flood height might be reduced by reservoirs about seven or eight feet.

Flood water coming into the lower Mississippi results from the various tributaries building up a wave in the Mississippi River itself. This wave is increased as it passes down the Valley by waters from the St. Francis and by waters from the Arkansas, the severity being determined somewhat by the relative coincidence of the various tributary floods. For example, if a flood wave reaches the mouth of the Arkansas, at the time a flood wave from the Arkansas reaches the mouth, a higher stage will result below the mouth of the Arkansas than if there were no coincidence of the flood crest. The adopted project for the Mississippi contemplates a so-called super-flood which was determined as the maximum probable flood. The specified gauge heights at various key points along the river are determined and the levees are constructed to accommodate those heights. In addition to levees, the project includes a diversion through the so-called Boeuf flood-way and escape channels at the mouth of the Atchafalaya.

The estimated cost of a high dam reservoir system on the tributaries is $1,125,000,000. The Federal Government

has already expended $450,000,000 and local interests have spent an additional $150,000,000 on the flood control and navigation project on the Mississippi.

Flood control on the Mississippi cannot be accomplished by the development of a reservoir system on one of the main tributaries alone, but such a development on one of the main tributaries, such as the Tennessee, will be of material help, provided there is sufficient storage which could be so operated as to control the contribution of that tributary.

The plan which we have adopted is that of levees and escape channels. We have considered supplementary control by means of a comprehensive system of reservoirs, the manner in which this supplementary control would affect the adopted plan and the possibility of eliminating certain uncompleted features of the adopted plan by means of reservoir control. In this general system is included a series of reservoirs on the Tennessee River and its tributaries. That system includes Norris, Wheeler, and Pickwick Dams with others.

The levee system as now constructed requires certain annual maintenance and in times of high flood there is additional flood fighting cost. If a substantial reduction of flood crests can be obtained, the annual maintenance and flood fighting cost will be reduced. This is in the nature of a general benefit throughout the entire area. We know it exists, but it is difficult to evaluate it in dollars and cents. There are about 20,000,000 acres in the alluvial valley of which the present levee system completely protects about twelve. There are about 8,000,000 acres of nonprotected land on the east side of the Mississippi in two units, one just below Cairo and the other just below Vicksburg. There are backwater areas at the mouth of the St. Francis, the White, the Arkansas, the Yazoo, and the Red. These backwater areas are caused by the tributaries com-

ing into the main stream. If the flood heights of the main river are reduced, a strip of land around the edge of each backwater area is protected so that reservoirs, by reducing flood heights, always protect a strip of land around the edge of these backwater areas. A change in stage of one foot at the time of a high flood will protect about 235,000 acres from flood.

Another general benefit results from the extensive drainage system constructed in each one of these side basins along the river. There is a canal running down into the St. Francis, into the Yazoo and into the other basins. If the backwater elevation is lowered the outlet for these canals is lowered, resulting in an improvement of drainage generally throughout the entire area affected. The accomplishment of lower stages throughout the Mississippi in any flood, whether it is one that would break the levees or one that is within five feet of the top of the levees, is of considerable benefit in all the ways just mentioned.

A flood-way is an escape channel for the diversion of water from the river other than through the main channel. A serious problem has arisen in connection with the use of flood-ways. The one at the mouth of the Arkansas has not been completed due to the fact that local interests obtained an injunction preventing the United States from proceeding with the contract to build the levees. This injunction was later dissolved by the Supreme Court, but the dispute exists as to whether the United States must pay for flowage rights, and damage suits to the extent of probably $100,000,000 are now pending. If sufficient waters can be held in reservoirs on the tributaries so that this section of the river can carry the entire flow, the use of the flood-ways would be unnecessary and they could be eliminated.

The general scheme involves a total of about 93,000,000

acre feet of storage of which 10,500,000 were allocated to the Tennessee River and its tributaries. We planned to provide 4,500,000 feet in four dams on the main stream, namely, Aurora, Pickwick, Wheeler and Chickamauga. The balance of the storage was to be provided by 17 dams on the tributaries including Norris.

I prepared this report under the general direction of the president of the Commission. The information for the report was obtained by requesting the various district officers to submit data. The data for the Tennessee was obtained from the Chattanooga district. Among the specific questions asked was that each district should submit the reservoirs that would be included in the best system for control of Mississippi River floods. By districts I mean the districts of the engineering department. (Counsel then offered in evidence a group of letters, the first of which was from the Mississippi River Commission dated April 26, 1932, on the subject "Request for Data for Comprehensive Reservoir Report, Mississippi River," to the Division Engineer, Upper Mississippi Valley Division, St. Louis, Missouri. Objection to these letters was sustained and an exception taken. They were marked for identification as Defense Exhibit No. 22.)

The dams which the Mississippi Valley Commission contemplates include the group now under construction and other covered by House Document 328.

The floods on the lower Mississippi originate from flows from the upper tributaries. There may be high flows and there may be a combination of high flows or moderate flows. We have made a very extensive study of the way in which we might get the so-called super-flood at Cairo. We find moderate flow out of one tributary and high flows out of three others. To get a flood, however, requires that there be a flood on some of the tributaries. We cannot put to-

gether low flows and get a flood at Cairo. There must be some high water on the upper Mississippi, the Missouri, the Ohio or the Tennessee and Cumberland. The Ohio is always a large contributor, and the Tennessee is usually at least a fair contributor. We can expect at least 100,000 to 200,000 second feet out of the Tennessee. This will vary, of course, with the flood. It is not necessary for all tributaries to be in flood. For instance, in the 1927 flood on the lower Mississippi River, the Tennessee River was not particularly high. It was flowing between 100,000 and 200,000 second feet, less than bank full.

Low dams on the tributaries of the Mississippi would accomplish no useful purpose for flood control.

It is possible to predict flood stages above 52 feet at Cairo for a period of approximately seven days prior to their occurrence. Cairo is considered the key point at the upper end of the lower river. In our general system of operation, we plan to divide all the reservoirs into two groups—those within the seven day prediction distance of Cairo and those beyond this distance. Those within prediction distance would be operated on predictions of the Cairo gauge, and those beyond would be operated partly on this basis.

Norris and other dams of that character are slightly beyond the prediction limit. It would operate part of the time on the general basis, and part on prediction basis. It is not strictly within the prediction limit but is on the fringe. In operating Norris on the basis of the predictions of the Cairo gauge we might miss the proper time for flood control operations by a couple of days. With the other reservoirs, which are further back in the tributaries, the difficulty increases. The high dam reservoirs on the Tennessee are within prediction distance.

The method of operation is as follows: We have a system of tributary dams and the supplementary system along

the main stream. When a critical stage is predicted at Cairo, we would place in operation the dams on the tributaries. Most of these have sufficient storage to hold the flow throughout the critical period. These would be put into operation and the main stream dams held in reserve. When the critical time came the main stream storage would be available to make up for inaccuracies in the operation of the tributary dams and to take off the flood flow at exactly the point desired. At a dam like Aurora, for example, which is less than, or approximately, a day from Cairo, we could let the water pass through when it was doing no damage and shut it off at just the proper time. The two work very well together. The tributary dams catch a large part of the flow and the storage on the main stream dams operates as the final regulator.

The peculiar advantage of the main stream dams, Aurora, Pickwick, and Wheeler, is that they are close enough so that we know what the water released from them will do at Cairo. We know how it will affect the crest and if it is obvious that it will cause no damage, we can pass it through. The reservoirs would be drawn down as fast as possible, getting rid of the water at a time when it would do no damage, and then if we see it is going to cause damage, we would shut them off and hold the water back. In this way water can be released in advance of the predicted flood crest so as to lower the levels in the pools. We have not put this into operation, but we have carried our studies far enough to see that it could be done.

Our studies showed that Norris has ample surcharge and possible drawdown so that if properly used it will be useful in alleviating the destructive flood waters on the Mississippi.

Where we have a flood on one of the other main tributaries, we can alleviate the situation by withdrawing the low or moderate flow on the Tennessee in an amount suf-

ficient to accomplish a reduction of the crest that would otherwise obtain at Cairo when the flood waters from the other tributaries reach that point. The converse is also true—that is, if you have a flood situation on the Tennessee with a probability of an acute flood on the Mississippi and moderate waters on the other tributaries. The Tennessee reservoirs are a part of the general system and operate in relation to the general system. This is on the assumption that the other tributaries are also reservoired.

Proper flood control operation of the various dams on the main tributaries would be very difficult unless under one unified coordinated control, and I think it would require unified control to be carried out successfully. With this prediction system, daily and perhaps at times hourly, operations are necessary. The dams must be coordinated with each other. Each of the dams must be operated with respect not only to the general situation at Cairo, but also with due regard to the situation existing at each of the other dams on the Tennessee.

In addition to having the District Engineer's report on the best system for Mississippi River flood control, we had each district formulate the best plan for control of the local floods on that tributary. We find that when we combine the effects of all of those systems, we obtain 60% of the effect that would be obtained if they were operated strictly for the Mississippi. Of course, that is taking two opposite extremes, and an intermediate plan of operation would have an intermediate result.

Wheeler and Pickwick Dams would be useful for flood control purposes because they control storage whereas natural valley storage, so-called, is a moving thing. As the flood wave passes down the valley, it occupies successively various portions of the valley. The term storage

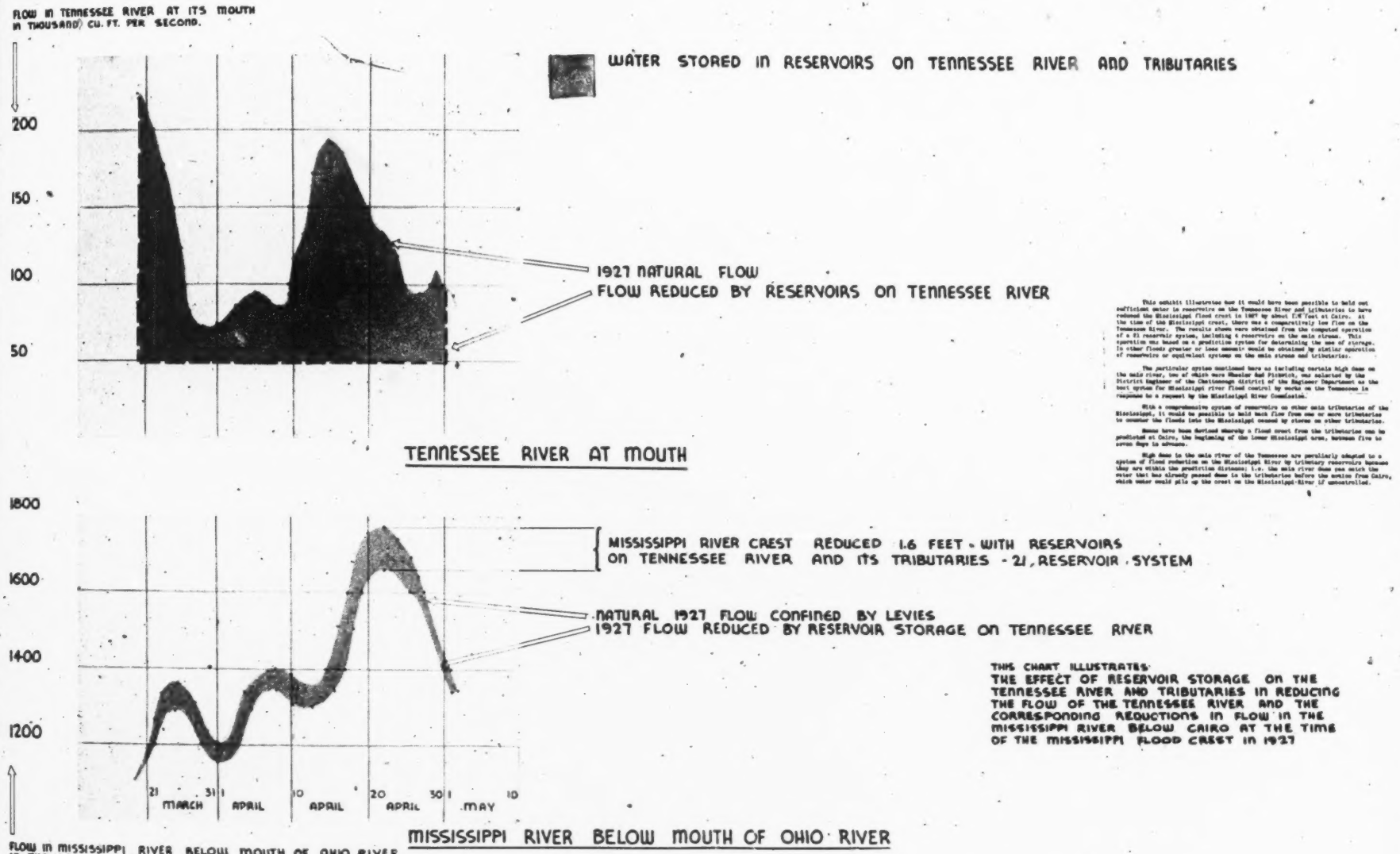
is perhaps a misnomer as the water is not stored but merely passes through. It is an uncontrolled wave that passes eventually out of the river, no portion of it being retained. The only way in which this natural storage can be controlled is by means of high dams. (At this point the witness identified a chart illustrating the effect that might have been obtained on the Mississippi River below the mouth of the Ohio from the Tennessee River and tributary reservoirs operated in the interest of Mississippi River flood control in the floods of 1926 and 1927. The chart was introduced in evidence as Defense Exhibit No. 23. It contained a typewritten statement of the facts illustrated. This exhibit is reproduced on the opposite page.)

The peak flow in the Tennessee River at the time of the Mississippi River crest was slightly under 200,000 cubic feet per second. (The witness went on to describe the various lines on the chart.) It would have been possible with a 21 reservoir system to have reduced the flow of the Tennessee River to 50,000 c. f. c. This would have reduced the crest at Cairo 1.6 feet. This reduction would have been a very substantial benefit.

I have a copy of the chart from House Document 328 which was used by Colonel Randolph. With so-called valley storage, space is not all occupied at the same time. As the flood wave passes down the valley, it occupies successive areas so that a comparison of the percentage of new storage with the valley storage must take into consideration the fact that with the latter certain storage space is occupied at different times. The most important fact is that valley storage is uncontrolled. (The witness here identified a chart illustrating the effect of control storage and of valley storage. It was introduced in evidence as Defense Exhibit No. 24, a reproduction of which appears upon the opposite page.)

Defense Exhibit No. 23.

EFFECT OF TENNESSEE RIVER STORAGE ON 1927 MISSISSIPPI RIVER FLOOD - BASIC DATA BY G.R. CLEMENS



This exhibit illustrates how it would have been possible to hold out sufficient water in reservoirs on the Tennessee River and tributaries to have reduced the Mississippi flood crest in 1927 by about 1.6 feet at Cairo. At the time of the Mississippi crest, there was a comparatively low flow on the Tennessee River. The results shown were obtained from the computed operation of a 21 reservoir system, including 6 reservoirs on the main stream. This operation was based on a predictive system for determining the use of storage. In other floods greater or less amount would be obtained by similar operation of reservoirs or equivalent systems on the main stream and tributaries.

The particular system mentioned here as including certain high dams on the main river, two of which were Wheeler and Pickwick, was selected by the District Engineer of the Chattanooga district of the Engineer Department as the best system for Mississippi river flood control by works on the Tennessee in response to a request by the Mississippi River Commission.

With a comprehensive system of reservoirs on other main tributaries of the Mississippi, it would be possible to hold back flow from one or more tributaries to counter the floods into the Mississippi caused by storms on other tributaries.

Dams have been devised whereby a flood crest from the tributaries can be predicted at Cairo, the beginning of the lower Mississippi area, between five to seven days in advance.

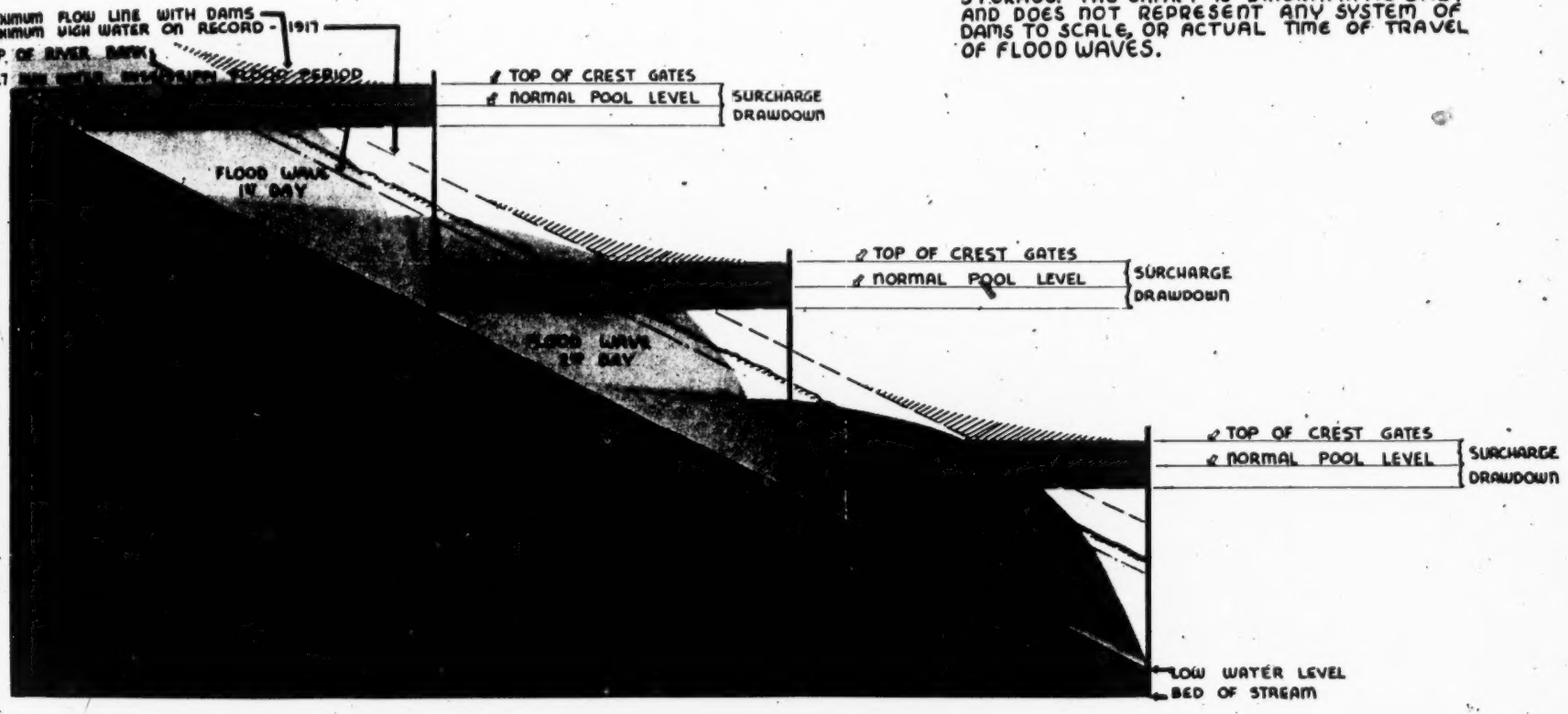
High dams in the main river of the Tennessee are peculiarly adapted to a system of flood reduction on the Mississippi River by tributary reservoirs because they are within the prediction distance; i.e. the main river dams pen which the water that has already passed dams in the tributaries before the surplus from Cairo, which water would pile up the crest on the Mississippi River if uncontrolled.

THIS CHART ILLUSTRATES
THE EFFECT OF RESERVOIR STORAGE ON THE TENNESSEE RIVER AND TRIBUTARIES IN REDUCING THE FLOW OF THE TENNESSEE RIVER AND THE CORRESPONDING REDUCTIONS IN FLOW IN THE MISSISSIPPI RIVER BELOW CAIRO AT THE TIME OF THE MISSISSIPPI FLOOD CREST IN 1927

Defense Exhibit No. 24.

CONTROL OF STORAGE BY HIGH DAMS ON MAIN RIVER.- BASIC DATA BY G.R.CLEMENS

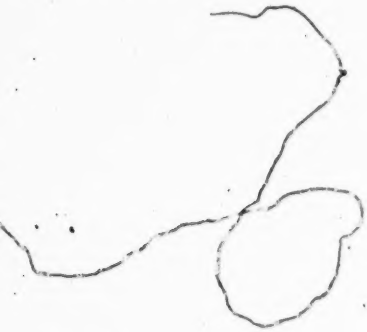
THIS CHART ILLUSTRATES
THE ADVANTAGES OF STORAGE CONTROL BY HIGH DAMS OVER THE SO-CALLED NATURAL VALLEY STORAGE. THE CHART IS DIAGRAMATIC ONLY AND DOES NOT REPRESENT ANY SYSTEM OF DAMS TO SCALE, OR ACTUAL TIME OF TRAVEL OF FLOOD WAVES.



This chart shows that it is a moving flood wave that occupies successive portions of the so-called natural valley storage of the river. Not all of the storage is occupied at one time, nor is there any control of the water so occupying the natural valley. In any system of flood reduction it is this control of storage that is important. Reservoirs could be operated to abstract portions of the flood wave and hold it back after the wave had passed. They would be capable of abstracting the water at whatever point of the wave was most desirable.

There is also indicated on the chart the fact that the volume of the reservoir above the flood flow line of the storage in excess of the so-called natural valley storage varies with different flood heights. In other words, there would be much more reservoir storage in excess of the 1927 high water mark during the period of Mississippi River flood than there would be in excess of the high water mark of the 1917 flood.

The chart also shows that above the surcharge elevation of the pools there would be a valley storage area due to the slope of high floods in passing through the reservoir pools.



As a flood wave passes down the valley, it traces with its crest the maximum flow line of the flood and occupies on different days various portions of the valley. The portion that it occupies is called the valley storage. If dams are placed in the river it is possible to retain a part of the flood wave within the pool. The portion which may be so retained above normal pool level we would call the surcharge, or if retained below normal pool level, it would be termed the drawdown. The volume of the reservoir in one flood will differ from the volume in another flood so that if the 83% represented the volume in excess of a maximum flood, there would be a greater excess percentage over some smaller flood. In addition, there is, with high dams, a certain recovery of valley storage in that the high water profile will be increased in back of the dam and there will be certain temporary storage above the pool level so that we recover some valley storage in the upper portion of the pool. I bring this out merely to show that valley storage is a moving thing and an uncontrolled thing, and whatever its percentage may be, if we take account of it in routing flows in a series of reservoirs we properly allow for it.

Storage conditions differ with the size of the flood. Above the high water level of 1917, we would have 83% storage. Above the 1927 high water level, there would be a larger percentage. By a series of dams we may retain much more than 83% of the storage depending on the height of the flood and this storage would be controlled by a dam.

A high dams system is the only way of using the natural storage in the channel. The low dams permit the flow to pass through at high water stages. In that way we would retain water in each of the reservoirs whereas the uncontrolled flood passes on out of the river. With the high

dams we can control the flow into the Mississippi and thereby reduce the crest.

To obtain flood control and navigation on the Tennessee and flood control on the Mississippi would require some unified control.

If I were instructed to construct works on the Tennessee River and its tributaries, to improve navigation on the Tennessee River, to reduce floods in the Tennessee River basin, and to reduce floods in the Mississippi River basin, I would build high dams in the main river such as Pickwick and Wheeler and storage dams on the tributaries such as Norris. I believe that is the only way in which the three purposes can be combined. Other means would accomplish one or the other of the purposes, but to accomplish all three requires that type of development.

Upon **Cross Examination** the Witness Testified as Follows:

In the studies which I have made with reference to the control of Mississippi flood waters, we included 21 dams on the Tennessee River system, both on the main river and on the tributaries. This is part of a plan for general head water control of the Mississippi which would cost about $1,125,000,000. These reservoirs would reduce the so-called super-flood on the lower Mississippi by approximately seven feet. 1927 was somewhat less than a super-flood year. It was the most destructive on record and the highest recorded at a number of places along the river. In some places it was exceeded by other floods. This flood, however, is commonly termed the greatest flood of record.

Observations of the flood conditions on the Mississippi River have been recorded for at least 50 years. No super-flood was recorded during that time. There undoubtedly has been one, but we have no record of it.

The seven foot figure was based on control of Mississippi River floods rather than local floods. If the reservoirs were operated solely for tributary protection, reduction would be approximately four feet. If the system were used for Mississippi River control, the tributary benefit would be about $350,000,000. If used for tributary control, the tributary benefit would be about $550,000,000, so that although we get a lesser reduction we have much larger local benefits.

As to the Tennessee River, we have additional information that was not available at the time House Document 328 was prepared, and we have conducted further studies on a much more comprehensive scale. The report on the Tennessee basin was prepared in 1932. I believe the only recommendation of the chief of engineers who was the ultimate authority for House Document 328, was for the navigation project of low dams with the provision for possible high dams as set out in that Document.

The chart which I prepared was based on the assumption of a 21 dam system on the Tennessee River operated for lower Mississippi control. However, the Tennessee is peculiarly adapted to that type of control with high dams. We considered only four locations on the main river for high dams. It was considered that 10,500,000 feet of storage on the Tennessee River was sufficient and that four main river dams would be sufficient. The dams which we considered were Three Springs, Tampico, and Strawberry Plains, on the Holston; Solomon Ferry on the Nolachucky, Bandridge on the French Broad, Davis Ferry on the Little Tennessee, Cove Creek on the Clinch; Millikan Branch on the Obed; Wartburg on the Emory; Coleman, Austral, and Charleston on the Hiawasse; Wann Hollow and Shoal Creek on the Elk; Bear Creek on Bear Creek; Chapel Hill and Cotty on the Duck; and Chickamauga, Gen-

eral Joe Wheeler, Pickwick Landing, and Aurora on the Tennessee. This list was submitted by the United States Engineers' Office at Chattanooga as the most effective group of reservoirs on the Tennessee River and its tributaries for flood control on the lower Mississippi.

This information was procured prior to the establishment of the Tennessee Valley Authority. We did not call on the Authority for additional information as we did not feel we needed any. There would have been no occasion for it to volunteer any information. I, personally, was not asked for information as to the effect of that program. I don't know and would not be in position to know whether information was requested from members of the Commission.

My immediate superior is General Harley B. Ferguson. I do not know whether or not he was a member of the Muscle Shoals Commission. He is an officer of high standing in the Corps of Engineers. He is a member of the Commission and in charge of the office of which I am on the staff.

I have made no independent calculation as to the effect of Norris alone at Cairo but only as a part of the 21 dam system. In making our comprehensive plans, we used a figure of about 1,000,000 acre feet less than that submitted by the Chattanooga district. The difference was principally at Norris Dam. Our plans were based on the assumption that there would be 10,500,000 acre feet storage capacity distributed between the tributaries and the main river in the ratio given. It was immaterial whether we used four or six dams in the main river. As long as the storage space was provided, we could accomplish the result. We were assuming that the storage space would be available for flood control use when necessary. The method of operation or of dispatching would have a definite and

important bearing upon the result. Any conflict with power would have to be worked out under unified control. At other times, it might be advisable to use it for different purposes. The operation of the dams would depend principally upon the gauge readings at the various places throughout the entire basin, but we would not have to predict the rainfall. It is impossible to predict rainfall, but it is possible to predict gauge heights. Rainfall is not an important element to be considered in the actual operation.

If control were delegated by some sort of regulation or licenses such delegation might have material effect on the result of the operation. But if the man in charge is responsible to a central agency control could be accomplished. The general mode of operation might be so directed as to accomplish primarily protection of the lower Mississippi or emphasis might be placed on the protection of the flood areas of the Tennessee River. The results accomplished are only comparative in either case. One matter may get a little more and the other a little less, but whether operation is primarily for Mississippi River control or for local flood control we still accomplish something on the Mississippi.

Even if it were operated solely for power production it would not be possible that there would be no flood control benefits, although such benefits might be relatively small. If the project is operated solely for power, the reservoir is held as high as possible at times, and when the flood comes it spills. In such case, however, there is storage above the spillway level which is more effective as valley storage than the low valley storage at the bottom of the river. A development for power alone might have a relatively small effect in reducing flood heights, but there would be at least a slight reduction of the maximum heights of

the floods by reason of the wider extent of the pool area which is flooded. A person operating a power dam is not going to permit more water to run over the dam than is allowable as otherwise there is damage and the man below must prove simply that his flood stage has been increased.

The chart which I have used is diagramatic and applies whether or not the width of the channel is uniform.

The report to which I referred has been signed by the Mississippi River Commission and forwarded to the Corps of Engineers. It has not yet been submitted to Congress and until so submitted, it is considered confidential under the applicable regulations.

I do not know whether the Commission has been consulted with reference to the design and plans for operation of the dams on the Tennessee River. They know that they are being built and they asked me to give them an estimate of the effect of reservoir projects on all the tributaries of the Mississippi under consideration.

I have read portions of House Document 328. The statement of the Mississippi River Commission which appears on page 101 with reference to the Tennessee River project to the effect that "the benefits to the lower Mississippi may be considered as practically immaterial" was made prior to the additional studies and without the benefit of these additional studies and additional information which they now have. It is superseded by subsequent studies. The Mississippi River Commission has information which was not available to the Corps of Engineers at the time House Document 328 was prepared in that we have all the records since that time. We have the other advantage of having since considered the Tennessee River as part of the entire plan instead of as a separate entity. The highest flood occurred in 1917 and House Document 328 had the data in it as to flood damage on the Mississippi and

Tennessee Rivers, but it did not have all the data as to the function of the Tennessee River in a general comprehensive scheme. This has been determined subsequent to House Document 328 and is embodied in my report.

This report has not been released and has never been turned over to Tennessee Valley Authority. Certain official data has been discussed with its representatives. It has been discussed with reference to the preparation of this trial and I discussed certain of the facts with Professor Woodward in a casual conversation last November. This was not in connection with this litigation. The recommendations and conclusions embodying the report have never been discussed.

I have no knowledge as to whether or not the Tennessee Valley Authority has asked aid, assistance, or advice from the Mississippi River Commission in connection with its program.

With reference to the following excerpt from House Document 328: "The operation of the storage reservoirs on the Tennessee for the primary purpose of restricting floods in the Mississippi Valley, would have no very great effect on the plans for flood control but would seriously injure the value of the power possibilities of the Tennessee basin," my comment is that the Chief of Engineers at that time did not have the information as to the effect on a comprehensive system. If the storage space were used entirely for flood control it would reduce the amount of power, but I don't know that it would seriously injure it. Whether it would reduce the amount of prime power or the amount of secondary power, I wouldn't want to say. I don't know the maximum pool length involved in the Pickwick and Wheeler Dams. I am acquainted with studies furnished by the Chattanooga district in 1932 which gave a tabulation of the time necessary for water to

travel from certain points to the mouth of the river and the capacities of the reservoirs.

We considered about 1,800,000 acre feet of storage available at Cove Creek. We reduced somewhat the figure in the district office. This capacity is equivalent to 900,000 c. f. s. for one day or 100,000 c. f. s. for nine days. That is, if the reservoir were entirely empty and water was flowing into it at the rate of 100,000 c. f. s. it would take nine days to fill the reservoir.

SHERMAN M. WOODWARD,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as follows:

I reside in Knoxville, Tenn. I am a teacher and practioner of hydraulic engineering. I graduated from the engineering college of Washington University in St. Louis in 1893, and have been engaged in hydraulic engineering ever since. For three years I was a member of the staff of the Irrigation and Drainage Investigation of the U. S. Department of Agriculture which is now a part of the Bureau of Agricultural Engineering. For seven years I was consulting engineer of the Miami Conservancy District which carried out a $30,000,000 flood control project around Dayton, Ohio. For several years I was consulting engineer of the Chicago Sanitary District. For about two years I was consulting engineer on a flood control project at Pueblo, Colo. I have worked as consulting engineer for various railroads and cities, private engin[illegible] numerous drainage districts in a half dozen different states, and at various times for the U. S. Government. For the last 25 years I have been professor of mechanics and hydraulics at the Engineering College of the State University of Iowa. At present I am on leave of absence as an engineer-

ing consultant with the Tennessee Valley Authority, and as a consulting engineer for the Muskingum Conservancy District which is now constructing a flood control and navigation project which will cost about $35,000,000.

My connection with the Tennessee Valley Authority began in June, 1933. My duties are to give opinions on all sorts of engineering questions that arise, usually of a complicated or involved nature, on which they wish my opinion. I have no administrative duties and I am in Knoxville about half the time.

The Mississippi Valley Committee of the Public Works Administration was appointed by Secretary Ickes as Public Works Administrator. Its first meeting, I believe, was held October 1, 1933. Its members are H. H. Barrows, Chairman of the Department of Geology of the University of Chicago, H. S. Crocker, of Denver, Colo., a very distinguished civil engineer, who, four or five years ago, was President of the American Society of Civil Engineers, Major General Markham, Chief of Engineers, ex-officio representative of the Corps of Engineers, who is usually represented at meetings by Lieutenant-Colonel G. E. Edgerton of the Corps of Engineers, H. S. Graves, of the School of Forestry of Yale University, C. H. Paul, of Dayton, Ohio, a very distinguished consulting engineer who has spent practically his whole life in connection with the construction of big dams, Harlow S. Person, consulting economist of New York City, at present Acting Chairman of the Committee, Morris L. Cook, consulting engineer of Philadelphia, who was Chairman of the Committee from shortly after its organization until last December, and myself.

The Committee was asked, at the time of its appointment, to study and prepare a long-time program for the

complete control and development of the waters of the Mississippi Valley, taking into consideration navigation, flood control, irrigation, water power, sanitary uses and forestry and soil erosion so far as they relate to navigation. By the Mississippi Valley, I mean the whole tributary and drainage area which takes in considerable part of 27 states and about 41% of the whole country.

We began work in October, 1933, and met about every second week for the next year. The various applications for funds that came before the PWA were referred to us for examination and opinion when they were particularly complicated and involved interstate problems. In connection with that we held hearings at which appeared representatives from all parts of the country, many types of engineers and people in public life.

After the first two or three months the Committee began the preparation of a report for PWA. At first most of our time was devoted to the study of this long-time problem, and we worked very intensively all last summer to complete a report which was delivered the 1st of October to Secretary Ickes. I devoted a large part of my time during the year 1934 to the preparation of this report. It purports to be the official expression of the opinion and findings of the Committee. It is signed by the whole Committee as representing in general their combined opinions.

The excerpt appearing upon page three of that report under the heading "Summary, Problem of Control" is in substance as follows: The problem of control of rivers involves not only the physical nature of the stream, but the often conflicting claims of various uses and users. Scientific planning requires a use pattern for each community, district or region, as well as a geographical pattern which will reflect as fairly as possible the dominant

needs of each locality. There is no one method of flood control which is applicable to the entire Mississippi system. The improvement of natural channels, the building of reservoirs—sometimes well adapted for purposes of irrigation and power; the construction of levees such as now exist along the lower Mississippi, reforestation and a change in certain areas from tilled crops to grass crops may all play a part in slowing down the rush of water to the sea, or in keeping it away from cities, towns and valuable lands.

That statement represents my opinion perfectly.

The excerpt upon page 23 of the report beginning with the words "A reservoir" is in substance as follows: A reservoir for flood protection is most effective if it is not far upstream from the lands to be protected. There is no doubt that the direct effectiveness of a reservoir is increased the closer it is to the area to be protected. Nevertheless, a reservoir constructed and operated for local flood protection on a tributary often, though not always, decreases to some extent the magnitude of floods on the main river. The records show that there have been no major floods in the Mississippi when the discharge of the Ohio at Cairo has been less than one million second feet. Navigation is particularly benefited by reduction of flood crests, and all of the possibilities of water use are improved by increases in flow at extreme low stages. It is sometimes possible to release water from flood control reservoirs to satisfy requirements for hydro-electric power development at the dam, or to regulate the flow downstream to the advantage of a variety of water uses. In such cases, equitable distribution of costs among the several purposes served may even sufficiently reduce the cost chargeable to flood protection to warrant the construction

of flood control reservoirs which could not be justified for flood protection alone. There is an apparent conflict between the use of the same storage reservoir for power development and for flood control. It is often possible to reconcile this conflict by allocating a certain capacity in the low portion of the reservoir for power storage and the necessary capacity in the upper portion for flood control storage. Often this combination would be much more economical than two separate reservoirs.

That statement also represents my opinion.

In its studies and investigations, my Committee found that projects in addition to those existing were needed or would be beneficial to afford better protection against floods in the lower Mississippi.

The adopted project referred to by Mr. Clemens calls for four items which are called flood-ways. The first is just below Cairo, Ill., on the Missouri side of the river. This is commonly called the Bird's Point-New Madrid flood-way. It starts at a point at the upper end called Bird's Point and it ends near the town of New Madrid. It is indicated on Defense Exhibit No. 21 by an orange-colored stripe showing the location of the protection or back levee. This area which is perhaps ten miles wide in the upper part is very highly developed and has valuable farms. The theory of the flood-way is that a very big flood will break over the levee close to the river and flood out that area. This back or protection levee will prevent it from extending into a very large area to the west. There is a second small flood-way about 30 miles above New Orleans which is six or seven miles long and about two miles wide. It will carry water from the Mississippi into Lake Pontchartrain, and will protect the City of New Orleans. The two big flood-ways are indicated in the

middle portion of the map. The Boeuf flood-way starts below the Arkansas, and reaches down until it approaches the mouth of the Red, coming into the backwater area of the Ouachita. This flood-way is about ten miles wide. The construction of these interior flood protection areas has not yet been begun. I visited this area six months ago, and I believe no work has been done at all because of the many obstacles which have arisen. The last flood-way is the Atchafalaya which contains areas on both sides of the Atchafalaya River. This river is an open outlet of the Mississippi which can carry the water to the Gulf of Mexico a long distance from its mouth.

Under this plan about one-third of the whole alluvial valley is consigned permanently to flooding. Half of the remaining two-thirds now has complete flood protection, but the other half is not sufficiently protected that it can be satisfactorily farmed and occupied at present. About one-third of the valley has no adequate flood protection at present and another one-third will be permanently consigned to flooding under the adopted plan. This one-third which is not completely protected is protected from overflow from the Mississippi but is subject to flooding from the tributaries. In the last few weeks great damage has been done on the Cold Water and Yazoo Rivers in the Yazoo basin. It gets no water from the Mississippi River, but still is greatly damaged by the tributaries.

Levees are planned to be built high enough so as to be above the highest water line reached in a flood. That margin above the high water line is called the freeboard. In the adopted project there is a one foot freeboard above the super flood line. There is a difference of opinion among those who have studied the question as to whether or not

more freeboard is needed. It has been urged from time to time that this is not sufficient margin of safety against breaking when unusually high floods occur.

Additional freeboard would make the levees much safer so that the danger of possible breaking would be reduced. When the water is up to that one foot freeboard line it is generally 20 feet higher than the land for 20 or 30 miles on both sides of the river. This is a very dangerous condition and the people are greatly worried. Additional freeboard could be obtained by building the levees two feet higher or by lowering the flood crest two feet. If only part of the reservoir system were built, it would lower the flood crest so as to obtain that additional freeboard. This is entirely feasible.

The levee system is about 1800 miles long and the average height is 21 feet. To raise the levees two feet would require an estimated 70,000,000 cubic yards of earth. A fair estimate of the cost would be $35,000,000 per foot; that is, $70,000,000 to raise the freeboard two feet.

The elimination of the flood-ways would be advantageous. It is doubtful as yet whether the right to flood them can be obtained. It will cost a lot of money to settle this question, but even if the right is obtained this will prevent any satisfactory use of the territory for other purposes as it is estimated that these flood-ways will be flooded every 10 or 12 years. The highways that cross the flood-ways will be flooded out and there are a number of these, some of which are now paved. There are also a number of important railroads which will be flooded out, which will interfere with commerce, causing a tremendous amount of damage and inconvenience. Every time a flood occurs, damage will be produced.

If the use of the flood-ways could be reduced, even

though they are not eliminated, this would be a great social benefit to that part of the country.

The Board of State Engineers in Louisiana has charge of all the levee districts, works and improvements and represents the state in cooperation with the Army Engineers in building levees. Since the flood-way plan was adopted, they have recommended in every one of their annual reports a modification of the plan by building enough reservoirs above so that the Boeuf flood-way and the Atchafalaya flood-way can be eliminated. Both of these are largely in Louisiana.

It is possible through the use of tributary reservoirs to reduce the use of the flood-ways. If you build enough reservoirs they can be entirely eliminated. If you build only a part of the reservoirs, you will reduce the frequency with which they are used.

There are additional benefits which might be derived from the reduction of flood peaks by tributary reservoirs. Wherever one of the tributaries comes into the Mississippi River, an opening is of necessity left in the levee system. When the Mississippi reaches a high stage the water flows back through this opening and covers a large backwater area. There is one at the St. John's Bayou, one at the mouth of the St. Francis, one at the mouth of the Arkansas, including the White, and the other large one at the mouth of the Red including the Ouachita which is a tributary or joins the Red just at its mouth. If the flood crest can be lowered, the backwater area will be correspondingly reduced. The Yazoo River on the east side also has a very large backwater area. That would be very valuable land if it could be removed from this flood menace.

I made an estimate from the best data available and found that lowering flood crests one foot would perma-

nently remove about 225,000 acres from flooding by backwaters.

Reduction of flood heights on the Mississippi by means of tributary reservoirs would reduce the expense of maintenance of the whole levee system, and also the incidental cost to all the people and towns near the levees which occurs in every high flood. Boats, navigation facilities, etc. must be pulled up above high water, and while it is perhaps impossible to estimate the amount, there is a great deal of inconvenience. Each foot that the high water mark is lowered would be of substantial benefit along the whole length of the levee system.

The reservoirs now under construction on the Tennessee are of the very best type to help to bring about the results which I have mentioned by lowering the flood crest in the lower Mississippi River.

The dams now under construction and other high dams outlined in the alternative plan of the Corps of Engineers will contribute very materially to flood protection in the Tennessee Valley, of which there is great need at present. Main river dams of the type of Wheeler and Pickwick will be valuable for flood control in the Tennessee Valley by reducing the maximum flow below the point where the dam is built.

Dams on the main stream of the Tennessee River are much more valuable for flood control in the Mississippi than are dams on the remote headwaters of the tributaries. Whether or not tributary storage dams would be of benefit to flood control on the Mississippi would depend upon their number. If it were possible to put in enough dams so that you could absolutely regulate the flow to a point where it would be uniform the year around, you would not need the main river dams, but this is physically impossible. The flood season or rainy

season is less than six months of the year, and enough dam cannot be constructed in the mountains to hold all the water that might come during that season and let it out during the summer. A practicable scheme requires main river dams to do the regulating so that the adjusting can be done by combining as effectively as possible with storage dams on the tributaries. The lower regulating dams will make the storage dams much more beneficial.

The dams now under construction by the Tennessee Valley Authority are all of the type that will fit in with the comprehensive system described by Mr. Clemens, and they are the very best ones to construct first in initiating that system.

If I were instructed as an engineer to construct dams in the Tennessee Valley which would improve navigation on the Tennessee River and reduce floods in the Tennessee Valley basin and in the Mississippi Valley basin, I would find it not only desirable but necessary to build both high dams in the main river, such as Wheeler and Pickwick, and storage dams on the tributaries of the Tennessee in order to accomplish all three purposes. I know of no other way to accomplish those three purposes by means of dams on the Tennessee or its tributaries. Dams on the main stream are necessary to secure the necessary regulation, and storage dams on the tributaries are necessary to supplement what the main river dams cannot do as they are limited to the quantity that they can store. Both are necessary to the system, and for navigation there is no question, it seems to me, but that you need the same system.

When the Tennessee Valley Authority was created the plans of the U. S. Engineering Department for the Cove Creek Dam were about half completed. I examined those plans and am familiar with them. There were no

essential differences between the Army plan and the design being used by the Tennessee Valley Authority. Many of the details were not worked out, and the plans were finished for the present construction by the Bureau of Reclamation in Denver, principally, but there was also a lot of work on the plans by the Tennessee Valley Authority engineers. There are some slight rearrangements of details but no essential difference.

There is no important difference as to flood storage space. I cannot remember where they put their flood storage line. The height is changed, I think, five or six feet. There was some rearrangement of the position of the power house and spillway, but esesntially they are just the same. There was no barge lift in the plans of the Corps of Engineers.

In my opinion it is not practicable to procure complete development of the Tennessee River for navigation and flood control in the Tennessee and Mississippi Valleys by means of private development of the various dam sites along the river. I know of no way by which a private power dam could be so coordinated for navigation and flood control.

Upon **Cross-Examination** the witness testified as follows:

As a matter of law papers might be drawn reserving absolute control under a license for the construction of the dams, but as a practical matter of administration, the carrying out of these provisions would be difficult. Proper operation of the dams would require someone in control who could control the operations without argument.

I have never read the Federal Water Power Act nor the regulations under it, although I have heard them discussed. I know that to some extent the United States is leasing the emplacements on federal controlled naviga-

tion dams for the purpose of the operation of hydro units on those emplacements. I know of no case in which complete control of the operation of pool levels in connection with a license has resulted in any lack of control to the authority reserving the right to operate. I am not familiar with the operation of pool levels under licenses granted by the Federal Power Act, nor with the operation under the direction of the Corps of Engineers of water gauges and pool levels by the Alabama Power Company at the locks which it has built for navigation purposes under grants from Congress. I do not know of any difficulties involved, because I have had no experience with federal licenses.

Congress has adopted the "adopted project" for the Mississippi Valley to which I have referred. About eighteen hundred miles of levees have been constructed or construction has been begun. At least 75% have been completed.

One of the flood-way levees is entirely completed from Bird's Point to New Madrid. Nothing has been done on the east protection levee of the Boeuf flood-way nor on the west protection levee except around the town of Monroe. A part of that ring levee had been constructed last summer. At Atchafalaya nothing has been done on the east protection levee. I think from 75 to 85% of the strengthening and raising of the eighteen hundred miles of main levees has been finished.

The reservoir system referred to by Mr. Clemens has never been adopted by Congress. The protection levees are part of the adopted plan, and were not included in the $1,125,000,000 estimate.

In estimating the cost of raising the levees, I have figured 50c a cubic yard. That includes the right-of-way and different expenses besides just the contract expense.

This is just a lump sum estimate. I do not believe that comparable work could be done for less. This would be a very difficult job, because it is the spreading out of the little work over a great area. It is not comparable with building a whole levee where the work is more concentrated. My estimate is roughly about $35,000,000 for an additional foot.

The plan which I have discussed is commonly called the Jadwin plan. That plan considered the question of storage reservoirs, but I do not recall the discussion very definitely.

Aurora Dam is the closest of the proposed dams upon the Tennessee to the Ohio River, and will be most favorably situated for flood control purposes. The Tennessee Valley Authority is discussing and investigating the construction of various dams, but I do not know which one will be constructed first. Aurora has been worked on a great deal and is being considered now by part of the staff. Guntersville has been studied a good deal, and various locations have been studied on the tributaries. Preliminary data is being collected. Before drawings are made, the location must be settled by a great many borings in the foundation. Perhaps they have begun plans on some of the dams, but it is preliminary data which is being obtained now.

I do not know how much work has been done on Chickamauga. I do not think White Creek has been mentioned. A location on the Hiawassee has been looked into and a dam on the French Broad has been studied a little. Locations on the Holston have been studied.

A number of different government departments have as their regular function certain water use studies, but I know of no other government agency that was doing the same sort of work that we were doing. The Committee

that was called the Mississippi Valley Committee is still in existence under the name of The Water Planning Committee of the National Resources Board. Under the Public Works Administration a National Planning Board was created which went out of existence in July of last year being merged in the present National Resources Board. The President's Water Planning Committee made a report in six weeks and went out of existence last spring. The Secretaries of War, Interior and Labor are members of the National Resources Board. The National Planning Board and five additional members are now the National Resources Board. There are various subcommittees on that Board.

I am not on the National Resources Board, but I am a member of the Water Planning Committee under the Water Resources Section of the National Resources Board. I am not on the body that devised the master plan to which counsel for the plaintiff has referred, and I have never heard of it so far as I recall. (The reference was to the Tennessee Valley Authority minutes in evidence as Plaintiffs' Exhibit No. 41-O, R., p. 557).

I have nothing to do with the electric program of the Tennessee Valley Authority and have made no recommendation about it. I have not been consulted as to its bearing on flood control either on the Mississippi or on the Tennessee. My work has been limited to flood control and navigation. It did not include the question of whether the dams would include hydroelectric units. I am not a power expert, and the emplacements were not considered by me as having relation to my work. My work included the hydraulic features in general, flood control and navigation and the strength of the structure and safety in every way. I have not considered the location of the lock from the standpoint of the distribution of power.

Upon **Redirect Examination** the Witness Testified as Follows:

The complete development of the Tennessee River by private interests would not be practicable. Private operation would be fatal with respect to public purposes.

The studies which we have made with reference to the proposed dams were preliminary to any decision as to their location. It takes a long time to select the proper place and determine whether the foundations are suitable.

The value of the tributary development is not limited by the alternative cost of raising the levees. One-third of the alluvial valley which is not cultivated at present because of flood damage, can be reclaimed by tributary reservoirs. There is no question but that in the future there will be a demand for protection of this unreclaimed area just as pressing as there has been in the past for the present system. These areas along the tributaries can never be protected by a levee and flood-way system. If this land is to be reclaimed it must be done with the help of reservoirs to lower the flood crest. The high crests in the lower Mississippi prevent proper drainage so as to permit the occupation of the land.

The two feet of freeboard to which I referred was not the result of the comprehensive system on the tributaries, but simply of that portion allocated to the Tennessee. The reservoir system on the Tennessee River alone can secure the additional two feet.

Upon **Recross Examination** the Witness Testified as Follows:

The following statement does appear upon page 22 of the report of October 1, 1934, previously referred to:

"In a general consideration of flood control by reservoirs, it should be borne in mind that the channel of a stream in flood constitutes a very effective kind of reservoir, because it is constantly making room for more water. A storage reservoir to be equally effective would either have to be of much greater area than the valley land under flood, or would have to provide storage at greater depth. The former requires availability of reservoir areas of relatively low value, and the latter requires favorable topographical features to afford feet storage economically."

It is true that I signed the report in which that statement appears, but if I were writing it I would not write that first sentence in that form at all. At the time it was read to the Committee, I did not like it and would have taken exception to it if I had had the opportunity. The report was a compromise on some matters, and I insisted upon the insertion of the following sentence upon the last page:

"While this answer does not embody all of the divergent views presented, it represents the opinion of the Comittee as a whole."

I did approve of the following excerpt from the Committee's report:

"Floods pay no attention to political jurisdictions. Any coordinated system of control will demand the cooperation of neighboring states with each other, as well as the cooperation of states with the Federal Government. Obviously the Federal Government should bear its share of cost and responsibility. Obviously, too, the states should do the same. To make this easily possible, we need uniform state flood control laws, federal legislation to expedite interstate compacts, and

a permanent policy of federal participation based on accurate estimates of the benefits to be derived. The integrity of state and local governments is certain to be impaired if the Federal Government is regarded as a kind of Santa Claus."

JOSEPH H. KIMBALL,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as Follows:

I reside at Knoxville, Tennessee. I am a civil engineer. I graduated from the Massachusetts Institute of Technology in 1894. After several years experience with municipal sanitary engineering in New England, I went to Louisville, Kentucky, on a $4,000,000.00 sewage and drainage project. In 1914, I went to Dayton, Ohio, and for ten years was with the Miami Conservancy District working upon the flood protection project, as assistant engineer, construction engineer, and assistant Chief Engineer. Thereafter, I made a flood protection study upon the Potomac River for the City of Cumberland, Maryland, and subsequently became principal assistant engineer for the firm of Metcalfe and Eddy of Boston. On September 1, 1933, I accepted a position in charge of the flood control section for the Tennessee Valley Authority. I am engaged in investigation and study of the flood control problem in the Tennessee Valley. I have made a study of the damage caused by past floods and have consulted the records and estimates of the Corps of Engineers.

There are numerous points along the river which are affected by floods including railroads, highways, farmlands, and small towns. The most vulnerable point is the City of Chattanooga. The Corps of Engineers made a study of past damages and concluded that the average annual

damage in the Tennessee Valley is about $1,800,000.00. I have considered the data upon which the estimate is based, and I regard the estimate as wholly inadequate. It covers past floods over a period of possibly 50 years, and the physical damage to the various pieces of property in the flood zone. There are many elements of damage that were not included. One of the most vital is depreciation in property value. Land which has once been flooded is ever after less valuable because of the flood menace. There are numerous other intangible damages including sickness and the epidemics which generally follow floods, possibly because of the unsanitary conditions caused by the floods. There is also a great blow to a life of a city as a whole. Business is paralyzed, the wage earner loses his wages, and the business man his income, and the city loses because of the depreciation of values.

Interruption of transportation and traffic is one of the chief damages. In connection with the point of intangible damages, I might mention that the railroad companies have usually kept records of damages, and have found in some cases that the intangible damages have exceeded the physical damages such as the loss of bridges, trains, etc. All of these elements are present in the Tennessee Valley.

The Corps of Engineers estimated the average annual damage at Chattanooga at $680,000.00. I consider this figure very inadequate. The largest floods at Chattanooga occurred in 1867 when the population was less than 5,000; in 1875 when it was less than 10,000, and in 1886 when less than 25,000. During these floods the flood stage exceeded 50 feet. It has never reached that height since. The population for Chattanooga in the 1930 census was over 119,000.

On the basis of a personal examination of the county

assessed valuation records, the property in the area within the zone of the 1867 flood is now estimated at $47,176,975.00. This figure is exclusive of public service corporations, railroads and street railways, telephone and telegraph companies, electric light and power, gas and water companies, express companies, and exclusive also of nontaxable value to the federal, state, county and city governments and the nontaxable property of churches, schools, religious, charitable and fraternal organizations. Including those, there is at least $75,000,000.00 worth of property in the 1867 flood area. The Reclamation Service has estimated that the maximum flood which should be anticipated at Chattanooga might be about 50% larger than the 1867 flood. I have made a considerable study of the conditions in the valley and floods in comparable drainage areas and I believe that this estimate is none too great. (The witness here identified a chart entitled "Tennessee Valley Authority—General Engineering Division, Chattanooga, Tennessee, Area Flooded Year 1867". The chart was offered in evidence as Defense Exhibit No. 25, which is omitted in this narrative.) The area shown in blue on the chart represents the water covered area of the city; the principal business section of the city is in these streets, Market, Broad and Chestnut, running from the river in a southerly direction. The industrial and manufacturing area is largely southeast of Main Street. The greater portion of both the business and the manufacturing area is within the flooded zone. The Union Station is within the flood zone, and all the railroads running from Washington and New York to Birmingham and the Southeast pass through the flooded area. So also the railroads running from Chicago and Cincinnati to Atlanta and Florida, and substantially all of the trackage and passenger and freight stations are within

the flooded district. (The witness here identified a chart entitled "Tennessee Valley Authority, General Engineering Division, Depth of Flood at Market Street and Rossville Boulevard, Chattanooga, Tennessee, Floods of 1867 and 1917." This chart was marked in evidence as Defense Exhibit No. 26, which is omitted in this narrative.)

The flood of 1867 reached a maximum of about 25 feet over Rossville Boulevard, which is not far from the center of the city. The flood of 1917 reached a depth of between 15 and 20 feet. Both of these floods would have covered a considerable part of the adjacent area. (At this point the witness identified a chart entitled "Tennessee Valley Authority, General Engineering Division, Depth of Flood at Main Street, Chattanooga, Tennessee, Floods of 1867 and 1917, February 5, 1935". This chart was introduced in evidence and marked Defense Exhibit No. 27, which is omitted in this narrative.)

Main Street is one of the principal streets in Chattanooga. The maximum depth of flood in 1867 was 20 feet on Main Street. In 1917 it was about 10 feet. Rossville Boulevard and Market Street run from a northerly to a southeasterly direction for a distance of about five miles across the city. Main Street runs southeasterly from the river to Missionary Ridge. Orchard Knob Avenue runs from a northerly to a southeasterly direction about parallel with Missionary Ridge. (The witness here identified a chart entitled "Tennessee Valley Authority, General Engineering Division, Depth of Flood at Orchard Knob Avenue, Chattanooga, Tennessee, Floods of 1867 and 1917, February 5, 1935." This was introduced in evidence as Defense Exhibit No. 28, which is omitted in this narrative.)

The maximum depth on Orchard Knob Avenue in the

1867 flood was 30 feet and in the 1917 flood was about 20 feet.

A flood in the nature of those described as shown on the exhibits would put the railroads out of business so far as that section of their operations is concerned. Transportation service in Chattanooga would be paralyzed until the necessary repairs could be made. Chattanooga is quite a railroad town. It is the point of intersection between traffic from New York and Washington to Birmingham and New Orleans, and from Chicago and Cincinnati to Atlanta and Florida.

A flood of this nature makes suspension of river traffic necessary. Terminal facilities would be drowned out.

The City of Chattanooga made some attempt to protect itself by the employment of an engineer after the 1917 floods. A report was made but no action was taken. No feasible plan has been worked out whereby the City of Chattanooga could solve the problem. There are great difficulties in the way of local improvement.

In the report made by A. L. Dabney, Hydraulic Engineer of Memphis, Tennessee, who was employed to study the problem, the following statement appears:

> "The network of railroad service tracks and railroad yards in the city are located very near the river bank, leaving available only a very narrow margin below the bank to be occupied by protection work. Distributed along these railroad tracks are a number of the large industrial plants of Chattanooga, each with its turnout and spur tracks. The railroads are generally 12 to 20 feet below a level grade, and in selecting any point for the levee to cross the tracks, the effect on these turnouts must be considered."

That statement represents my own opinion as to some of the difficulties.

I call attention to the fact that this report was made 18 years ago, and that Chattanooga has developed since then. Also to the fact that protection works without supplementary means would have to be of a considerably greater magnitude than contemplated by Mr. Dabney. The construction of local protection units has difficulties, and I do not see a possibility of complete local protection. It is possible by reservoir storage effectively to supplement local protection. This is a feasible, and, so far as Chattanooga is concerned, a very necessary method of supplemental protection in the Tennessee Valley. Even without local protection, the reservoirs would be of substantial benefit.

In the case of a severe flood, local improvement works of the magnitude contemplated in the past would be inadequate and would constitute a grave menace rather than a help. In speaking of the menace of inadequate protection, I would like to quote from a book entitled "Relief from Floods" by Albord Burdick, as follows:

> "When works are constructed, intended to protect a large population, a halfway measure is nothing less than a death trap. Anything less than adequate protection to a place of human habitation is worse than no protection at all, for it creates a false sense of security and multiplies the consequences of failure."

That statement represents my opinion. (At this point the witness identified a chart entitled "Operation of High Dams for Flood Control, Basic Data by J. H. Kimball." He further stated that the typewritten matter on the chart represented his testimony. The chart was introduced in

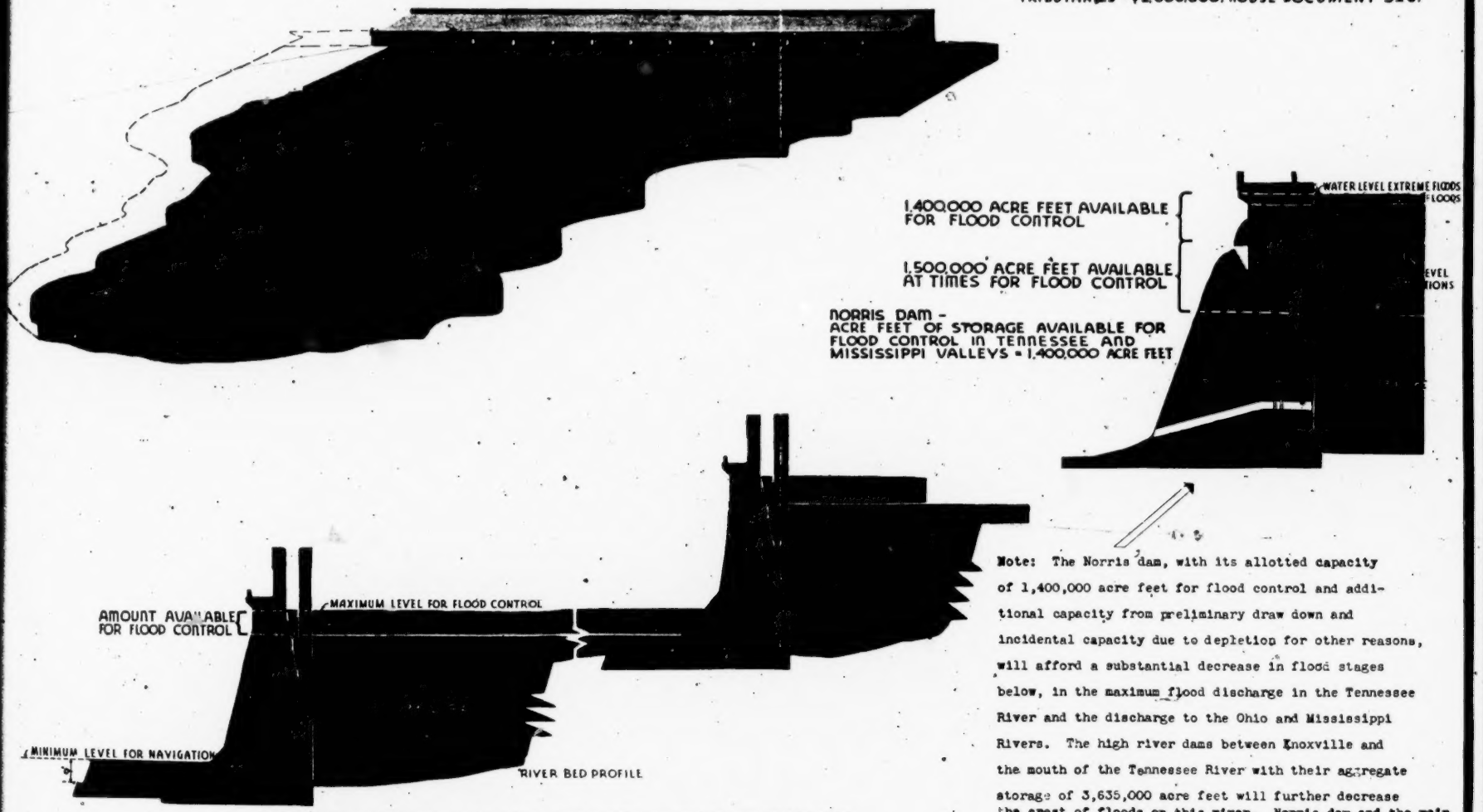
evidence as Defense Exhibit No. 29, a reproduction of which appears on the opposite page.)

Norris Dam is shown at the right of the chart. The dam is shown by the black area. Back of the dam in shades of blue are varying heights of water. (In reproduction this is shown in shades of gray). Between the two lower bright lines is the volume of 1,500,000 acre feet, which is the quantity which will vary under ordinary conditions. Above that point is another band of blue set aside especially for control of floods. (In reproduction this is labeled). The top space represents the normal 1,400,000 acre feet especially allotted to flood control. The area below this will also be available when the reservoir has been depleted for other reasons, such as replenishing the lower water flow of the river. Normally a storage reservoir will be depleted during the fall so as to have a volume available for flood storage. The top space will always be available and will never be used for any purpose but flood control. This dam will be most effectively operated by keeping the storage ready for occupancy when the flood waters above are turned into the Clinch River, where they will be retained and held until they may be released safely. This operation would have very substantial effect in reducing the flood depths at Chattanooga. In 1926, it has been estimated, that the flood stage at Chattanooga would have been decreased by 5.7 feet by this control. This is the flood of 1926 and 1927, and the estimate was made by the Army Engineers. It appears in House Document 328. This estimate was based on the storage of only 387,000 acre feet at Cove Creek (Norris). Present plans call for 1,400,000 acre feet. This would increase the amount of reduction at Chattanooga as it makes that much more available for control. The Reclamation Service has made studies of the effect of Norris Dam, as actually being constructed, on the 1886 and

Defense Exhibit No. 29.

OPERATION OF HIGH DAMS FOR FLOOD CONTROL - BASIC DATA BY J. H. KIMBALL

ESTIMATE OF CALCULABLE ANNUAL FLOOD DAMAGE TO TENNESSEE VALLEY BY TENNESSEE RIVER AND ITS TRIBUTARIES = $2,000,000. HOUSE DOCUMENT 328.



AGGREGATE CAPACITY AVAILABLE FOR FLOOD CONTROL IN TENNESSEE AND MISSISSIPPI VALLEYS PROVIDED BY THE SEVEN HIGH DAMS ON THE MAIN RIVER RECOMMENDED BY ARMY ENGINEERS = 3,635,000 ACRE FEET

Note: The Norris dam, with its allotted capacity of 1,400,000 acre feet for flood control and additional capacity from preliminary draw down and incidental capacity due to depletion for other reasons, will afford a substantial decrease in flood stages below, in the maximum flood discharge in the Tennessee River and the discharge to the Ohio and Mississippi Rivers. The high river dams between Knoxville and the mouth of the Tennessee River with their aggregate storage of 3,635,000 acre feet will further decrease the crest of floods on this river. Norris dam and the main river dams on the Tennessee River have over 5,000,000 acre feet of storage space available to control the contribution of the Tennessee to flood crests of the Ohio and Mississippi

1917 floods. It has been estimated that it would have caused a reduction at Chattanooga of 11.5 feet in the 1886 flood, and 6.7 feet in the 1917 flood. This is simply by the normal operation of the dam, and in my opinion these reductions could have been effected, and would have been very valuable. This estimate is based simply upon the flood storage space, and the benefit could be increased by operation of the draw-down. There would be times when this could be done.

Floods normally occur in the Tennessee Valley from December through March. During this time it is practically certain that a portion of the lower zone will be available.

The first dam above Chattanooga suggested in the alternative high dam program of the Army Engineers is Chickamauga. Above that on the main river is White Creek, and then Coulter Shoals. In carrying out the alternative high dam program, high dams would be constructed of the same general type as Wheeler and Pickwick. They differ from Norris in that Norris is a storage dam. That is, it may collect a large volume of water and hold it for weeks or months. A river dam delays the passage of water and the operation is somewhat different. The flood waves passing down the river are followed by depressions. The effect of a river dam is to take water off the top of a flood crest and push it into the hollows so as to even and lower the flood height.

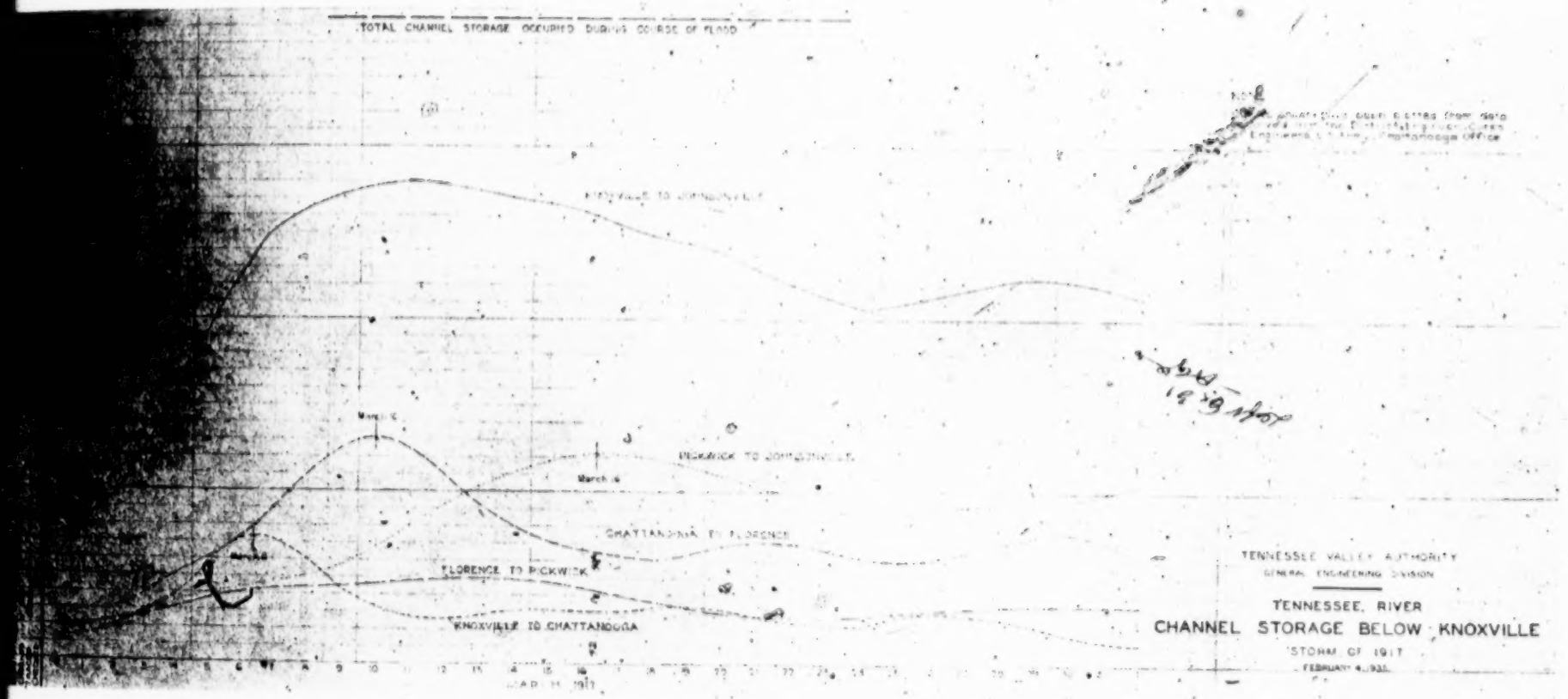
Over and above the level necessary to maintain a nine foot navigable depth in the river, the river dams have a height of 10 feet which is called the surcharge controlled by the gates on the dam. Even more than the 10 feet may be used.

When a flood is on the way, water can be drawn from the pool and the level lowered so far as consistent with

maintaining a nine foot navigation depth. When the flow is substantial that is sufficient in itself to produce a nine foot depth at the upper end, the water at the dam can be lowered more than 10 feet below the top of the dam and that much more is available for temporary control of the flood waters. On this chart the darker portion of the pool below is what is called dead storage, that is, water which is not affected and which is held at that height for navigation purposes. Above that is the distinct blue area representing the volume stored for flood control. (In the reproduction this is in light shading). That is the flood surcharge storage.

The construction of high dams in the main river would supplement the flood control effect of Norris. We have computed that Coulter Shoals, White Creek, and Chickamauga Dams, in addition to Norris, would have reduced the flow at Chattanooga in the 1917 flood so as to lower the gauge height from 45.4 to 30.3 feet. In the March, 1929 flood the reduction would have been from 38.5 to 22 feet. (The witness here identified chart showing surcharge storage provided to compensate for flood storage displaced by rising water. The chart is a reproduction of chart 23 appendix B, part 2, House Document 328. It was introduced in evidence as Defense Exhibit No. 30, which is omitted in this narrative). The chart shows the flood storage passing down the river in the natural condition. It indicates the sudden volume of flood waters shunted off to a higher basin and held there as long as is necessary by the gates at the top of the dam. (The witness here identified a chart entitled "Tennessee Valley Authority, General Engineering Division, Tennessee River Channel Storage below Knoxville, Storm of 1917, February 4, 1935." The chart was introduced in evidence as Defense Exhibit No. 31, a reproduction of which appears upon the opposite page.) This chart represents the passage of the flood

Defense Exhibit No. 31.



crest or the temporary channel storage from Knoxville through to Johnsonville. It was prepared by me and represents my opinion. It represents the storage in the 1917 flood from the actual flow records obtained from the United States Geological Survey water supply paper. It represents by a line designated Knoxville-Chattanooga the quantity of flood storage impounded within this section for the successive days indicated in March 1917, and in like manner the storage between sections between Chattanooga and Florence, Florence and Pickwick, and Pickwick and Johnsonville. The maximum storage in the Knoxville-Chattanooga section was reached on March 6. From Chattanooga to Florence, March 10; Florence to Pickwick, March 13; Pickwick to Johnsonville, March 16. When the storage reached a maximum between Pickwick and Johnsonville only 48% was retained between Chattanooga and Florence, 80% between Florence and Pickwick, and 22% between Knoxville and Chattanooga. The surcharge provided by the dams differs from natural storage in that the surcharge controls the storage, whereas in the natural flow that storage travels downstream. The figure of 83% which has been given as representing the relation between surcharge storage and natural storage has no meaning. It is like including in the population figures for a city people passing through on passenger trains, because that storage is a moving thing. The only way to get this capacity throughout the river at one time is through the operation of the surcharge from the dams.

Wheeler and Pickwick Dams are of value for flood control on the same principle. In the flood of 1929 the seven dams in the main river from Coulter Shoals to Aurora, together with Norris, would have reduced the gauge height below Aurora from 44.8 to 29 feet. This is an

illustration of the effect that can be obtained by run of the river high dams.

Each of the dams now under construction by the Tennessee Valley Authority is essential for flood control along the river. If I were instructed to build dams on the Tennessee River and by doing so to improve navigation on the Tennessee, and to reduce the flood waters in the Tennessee and in the Mississippi River Valleys, I would consider it necessary in order to carry out such instructions to build high dams in the main river, such as Pickwick and Wheeler, and storage dams on the tributaries, such as Norris. I know of no other way to accomplish those purposes.

Upon **Cross-Examination** the Witness Testified as Follows:

It would be physically possible to use a portion of the storage space for power.

The space below the intakes is dead water and there is no way of letting that water out of the reservoir. It is not useful for flood control.

The use of storage space for power would be an act of bad faith. Because the persons operating the dams are reputable persons, I must assume that it will not be so used.

Even if all the dams are installed, the low flow would be benefited by releases from Norris. I have not made any computation as to whether the low flow of the river is sufficient to actuate the locks.

In 1867 the flow past Chattanooga at the time of the floods was about 400,000 cubic feet per second. I do not know what the maximum flow at the site of Norris Dam was in the 1867 flood. Of course Norris Dam cannot stop

more than the maximum cubic feet per second flow past that point. I didn't estimate what effect it would have on the 1867 flood stage. I cannot give you the cubic foot per second flow at the Clinch, but in making our computations as to the effect at Chattanooga we took the actual flow at the Clinch based on the figures given by the geological survey and treated it as having been controlled. I do not now remember the figures. I have not with me any of the basic data on which my computations were made.

I have no computation sheets with me as to the control of levels below Aurora, nor as to the second feet in the Ohio nor in the Tennessee at that particular time.

Norris Dam and the proposed main river dams upstream from Chattanooga would all contribute very substantially to the reduction of floods at that city, but I cannot say offhand the relative amounts that each contributes. I have not the data available. Working together, Norris Dam and the main river dams have a combined value greater than the sum of the two working separately or the sum of the two individual benefits.

In making our computations we have made the assumption that the upstream dams were to be built eventually, but no immediate plans have been made for the construction of those dams.

The general studies which I have been making as to the effects on Chattanooga floods have been in progress for months. We started with rainfall studies and laid down the general foundation for the computation of routing floods through the system. We started with rainfall, the topographical, and other features of the water shed and the study of other stream flows elsewhere. This has been continuing for a long time. The Chattanooga problem has been coming to a head more recently. I cannot say

just when. This problem has been under consideration for some time.

To some extent I have studied the 21-Dam Project to which Mr. Clemens referred. My studies do not include power or navigation questions. The term "flood control" describes my field. This includes the effect of floods on the system, the method of handling floods, the effect of backwater on the towns in the valley and other related matters. It has nothing to do with the power operations of the Tennessee Valley Authority, or its plans as to hydro-units for the marketing of power.

Thirty feet is the flood stage at Chattanooga. I do not know at what point the flood commences at that stage. The stage in the 1867 flood was 58.8 feet. I do not know its duration. I know something of the plans of the city for its own protection. I know of only one estimate made for the city, the one made by Mr. Dabney of Memphis and that was inadequate.

The Reclamation Service made a rough guess that it would cost $20,000,000 to put a levee around the threatened area. I think that is a very conservative estimate.

(Counsel then read to the witness the following excerpt from Section 1-d of the Report of Colonel Tyler dated August 27, 1931, to the Chief of Engineers: "These three projects, all on the main Tennessee River above Chattanooga, offer greater flood protection to that city in the great majority of floods than would be secured through the construction of the Cove Creek Reservoir," and asked the witness whether he agreed with that statement.) That statement does not say how they compare, whether it is 5% advantage or 75%. I can hardly make any comment on that.

Upon **Redirect Examination** the Witness Testified as Follows:

The generators at Norris operate at full capacity on a head of 165 feet. They operate at maximum efficiency on this head and it is the most that does any good. The surcharge is at 194 feet. In other words, this flood storage surcharge is well above the maximum head for efficient production of power. There would be no benefit to power production there by diverting the flood storage.

On the general run of the river dams there would be no benefit to power production by diverting a part of the surcharge. If Norris Dam is emptied it will not fill in an ordinary season.

Upon **Recross Examination** the Witness Testified as Follows:

The generators at Norris are designed for certain conditions and service. No useful purpose is served by changing those conditions. I am not familiar with power generation, but I suppose that the increase in storage produces an increase in primary power.

EDWARD H. SARGENT,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as Follows:

I reside at Albany New, York. I am a Civil Engineer. I graduated from the Massachusetts Institute of Technology in 1907. From 1907 to 1920, except during the War, I was engaged in various capacities, finally becoming Engineer in charge of the Water Storage and Power Investigations in New York State, conducted by the New York State Water Supply and Conservation Com-

mission. During these investigations, which covered all the principal watersheds in New York State, field surveys and examinations were made of proposed storage reservoirs and power projects and comprehensive plans prepared for their development. In 1931 I was placed in charge of the Water Power Bureau of the New York State Engineering Department, also serving as Engineer for the New York State Power Commission in the supervision of licenses granted for power development at Niagara Falls. During this period I was also in charge of the designing of hydroelectric plants built by the State of New York at the Canal Dams at Crescent, and at Vicker's Ferry on the Mohawk River. Since January of 1923, I have been Chief Engineer of the Hudson River Regulating District.

The Hudson River Regulating District is a public corporation of the State of New York created under the conservation law which provides that river regulating districts may be created where necessary for the regulation of the flow of streams for the public welfare, including public health and safety. The district may be created upon petition of municipalities or private corporations, and once created, the members of the Board are appointed by the Governor of the State, and the corporation functions as a separate public corporation, entirely distinct from the State of New York, as such.

The plan for the regulation of the flow of the Hudson River, which was prepared under my direction, calls for the eventual construction of 16 storage reservoirs, of which only one has been built to date. This is the Sacandaga, which was built between 1927 and 1930. This reservoir was created by the construction of Conklinville Dam, about five miles above the confluence of the Sacandaga and Hudson Rivers. There was also a small privately built reservoir at Indian Lake which we intend to enlarge. (At this

point the witness identified a map entitled "State of New York, Hudson River Regulating District, General Plans Showing Available and Feasible Reservoir Sites." This was introduced in evidence as Defense Exhibit No. 32, which is omitted from this narrative.)

The Sacandaga Reservoir has a capacity of about 850,000 acre feet. The flood flows are impounded within the reservoir, thereby reducing floods on the Hudson River. During periods of low water the stored water is released to augment the flow of the Hudson River, for the purpose of improving navigation, bettering sanitary conditions and the development of power at the existing dams in the Hudson River. We are serving all three purposes.

By the actual operation of the dam we have obtained substantial flood control benefits. The gates of the reservoir were closed for the first time on March 27, 1930. At present the reservoir is about one-third full and although the flow of the Hudson is sufficient for the power plants, we are deliberately wasting water from the reservoir to anticipate the spring floods which usually begin about March 20. (At this point the witness identified a chart entitled "State of New York, Hudson River Regulating District, Hydrograph of Hudson River at Spier Falls, showing Sacandaga Reservoir regulation for 1933". This chart was introduced in evidence as Defense Exhibit No. 33, which is omitted from this narrative).

The area in green is water impounded during flood seasons. The reservoir rose from being nearly empty in late March to nearly full in late April. The month of June was a month of extreme low flow. The minimum flow was multiplied seven or eight times by the release of the water. At Spier Falls during that month 90% of the flow was water released from the reservoir. While the dam was closed the reservoir rose about 25 feet to within three feet of the crest.

At this time the floods in the Hudson had subsided to such an extent that I felt it safe to begin to discharge water in order to reserve a space three or four feet in depth from the top of the reservoir in which to store any flood which might subsequently occur. (At this point the witness identified a chart entitled "Effect of Sacandaga Reservoir on Flood of April, 1933. Basic Data by E. H. Sargent." This chart was introduced in evidence as Defense Exhibit No. 34, which is omitted from this narrative). This chart shows that by closing the gates of the reservoir we decreased the flood at Spier Falls from 56,000 cubic feet per second to 28,000 cubic feet per second which was the actual flow.

The Sacandaga Reservoir is also operated for low flow regulation. In 1933 the storage impounded during the April flood was released during the months from June to December to increase the low flow during that period. There are several reasons for regulating the low flow. For example, the river is polluted by sewerage from various cities, and waste from pulp and paper mills along the Hudson. The release of the low flow by the reservoir greatly improves the sanitary conditions in the river. It is also a large benefit to the existing power plants along the Hudson. The reservoir serves the purposes of flood control and navigation, sanitary improvement, and the generation of power in the river below. Power is also being generated at the reservoir. The hydroelectric plant consists of two 18,000 H. P. motors.

In actual operation we have found very decided conflicts between these different purposes. For example, at the present time the flow from the Hudson is sufficient to operate power plants at the various dams, but in spite of this I am releasing water from the reservoir in order to be sure of a space in which to store next Spring's floods. If the reservoir were operated entirely for power purposes

that would not be done because the Spring floods might not be sufficient to fill the reservoir and power production might be penalized because of the waste of water at the present time. The generation of power at the reservoir also presents a conflict at times. For example, we sometimes generate power at the dam in order to keep the reservoir down when it would not otherwise be generated, and we do not generate power at the time we are storing water when it might be generated at the dam if under private control.

These difficulties would probably not be met successfully by private operations. If a power company were operating the dam it would not be willing to sacrifice power for flood control, as we do. There was a proposition to develop this site by a private interest but not to the same capacity. The capacity of the project as proposed by the power company was largely for power and power alone.

The Indian Lake Reservoir was constructed by a group of power companies 37 or 38 years ago. It is operated entirely for power purposes down the river and they do not, as we do, deliberately waste water in the winter in order to obtain space for flood control purposes.

There is no definite space allocated in the Sacandaga Reservoir for flood control. The manipulation of the water is a discretionary matter with me. I am permitted to operate the reservoir so as to accomplish the purposes named in the Act. I must reconcile differences between the private interests below because of the different nature of the plants. The hydroelectric plants operate generally on a 12 hour basis, whereas the paper mills run almost continually on a 24 hour basis, so there is a difficulty in releasing water to meet their needs which is, of course, complicated by the hydroelectric plant at the dam.

I am generally familiar with the design of the Norris

Dam, and I understand that a total of 2,900,000 feet is available for low flow and flood regulation. Assuming that 1,400,000 acre feet is allocated exclusively for flood control, Norris Dam would, in my opinion, be a desirable and useful structure for the purpose of reducing or regulating flood flow. The definite allocation of storage for flood control purposes will make operation for the various purposes much easier. Since that amount is definitely reserved for flood control, it is not discretionary as in my case. Furthermore, the Norris Dam storage is greater per square mile of watershed at Chattanooga than is the Sacandaga storage on the square mile basis at Albany.

Comparing hydrographics of the Clinch River with those of the Sacandaga there is a marked similarity in the behaviour of the two rivers with reference to floods, except that floods in the Clinch are generally about two months earlier than on the Sacandaga, and we also have the snow problem that does not exist here.

In my opinion, and assuming that Norris Dam is to be operated for the purpose of controlling flood waters, improving navigation upon the Tennessee, increasing the amount of firm power at Wilson Dam, and for the incidental generation of power at Norris Dam itself, that dam as being constructed can be efficiently operated for all those purposes. My answer is based upon the similarity of that operation to the operation which I am conducting at the Sacandaga Reservoir. In my opinion, that dam could not be as efficiently operated for those combined purposes under private control. Assuming that a total of 1,400,000 feet of storage at Norris Dam is allocated solely for flood control, in my opinion that is more storage space than I would allocate if I were constructing that dam primarily for the purpose of flood control.

From the study that I have made from the stream flow

records on the Clinch River, it is doubtful that the reservoir would fill in most years, so I doubt if that amount of flood storage could be used except rarely. It may be that the rare use of that storage for flood control would entirely justify its allocation. Assuming that it is necessary to store 1,500,000 at Norris for low flow regulation, it would be possible to make a material portion of that amount of space available for flood control in a large part of the flood season just as we do on the Sacandaga. It would be a joint use of power storage for flood control purposes.

There are no navigation dams on the Hudson River South of Troy. Practically all of the flood control regulation is done at the Sacandaga Reservoir. There is some incidental regulation from other storage reservoirs built for other purposes. There is only a very slight attempt to operate main river dams below Sacandaga for flood control purposes.

Our flood problem is primarily at Albany but the various cities up the river have flood problems. Albany is 75 river miles from Sacandaga. We have no flood problem comparable to that of the Mississippi. Troy is about 70 or 75 river miles from Sacandaga. It is six miles from Albany. The stretch of the river from Troy to Sacandaga is well developed so far as dam sites are concerned, except for the fall of 152 feet between the Sacandaga Reservoir and the confluence of the Sacandaga with the Hudson. Below that point the dams exist in a series of steps and were there before the reservoir was built.

I have noted that private interests in the river below have had controversies about their respective rights in the river.

Upon **Cross-examination** the Witness Testified as Follows:

The New York Power and Light Corporation, a private concern, operates the hydroelectric plant at the Sacandaga Reservoir under a lease from the Hudson River Regulating District, by the terms of which the District retains complete control of the release of water from the reservoir.

The lowest dam downstream is one built by the Federal Government for canal purposes under the Federal Water Power Act. The Ford Motor Company has built a power plant there. I am not familiar with the control reserved by the United States. The next dam upstream is the Waterford Dam built by the State of New York to create a pool for a lock in the Champlain Canal. The only development at that point is one capable of producing sufficient power for lockage. It is operated by the State of New York. All of the remaining dams are privately owned dams with one small exception at Crockers Reef. They are used either for the generation of power or for the manufacture of paper and pulp. They were not constructed under licenses from the Federal Government as they have been in existence for a long time and there is some dispute as to whether the Hudson is navigable at that point. There are no other grants by the State of New York for the use of the waterpower of the Sacandaga Reservoir other than at the dam

I have complete control of the functioning of the Sacandaga Reservoir for the purposes which I have stated and am invested with discretion under the terms of the Statute authorizing the creation of regulating districts. The hearings incident to the creation of the district are held before the New York State Water Power and Control Commission, and the creation must be approved by the Commission.

The flood problem on the Hudson River is that of a

single river in a single state. The flood stages are felt principally on the Hudson River and not so much on the tributaries, although the tributary floods occur at different periods of the year and cause floods on the Hudson. There is no conflict such as occurs in the Tennessee basin between local flood control and Mississippi River flood control. The Hudson River watershed is entirely a state problem and there are no interstate conflicting interests.

I have had no personal experience with operations of hydroelectric plants which, or the sites of which, are leased under the Federal Water Power Act: At the present, I am not familiar with the scope of control reserved or authorized to be reserved to the Corps of Engineers as to the manipulation of pool levels on the streams under licenses granted under the Federal Water Power Act. In 1921, I was engineer for the New York State Water Power Commission which cooperated with the Federal Power Commission and I had some experience with licenses granted at Niagara Falls.

There is no difficulty in reserving absolute control of pool levels on any reservoir, but it would be difficult to make such reservation practicable in operation. I am not familiar with the leasing of emplacements on the Kanawha River or the control of the water.

At the canal dams on the Mohawk River, the State of New York built hydro-electric plants. I designed them and started construction. The state has leased that power to private corporations, but maintains and operates the plants themselves, because it did not feel it could allow the private corporations to operate those navigation pools. I think the reservation and the absolute manipulation of the pool would require also the operation of the power plant. The reason is not so much the difficulty of obtaining a trustworthy official to operate the pool levels as it is a matter of

coordination. At Sacandaga, the New York Power and Light Company operates the hydro-electric plants, but we reserve the right at any time to go in and close the gates. It would be impracticable for the United States Government to reserve similar control over waters on navigable streams, because the matter of a few inches of level is not as essential for us as it would be in the navigable pools. The difficulty in the coordination of the use of water for flood control, navigation, and power would make it difficult to get anyone to operate the pool from the standpoint of flood control and navigation unless they also operated the generating equipment.

The power plant at Sacandaga was leased with my approval. I have a resident engineer, and each morning I direct him how much water to release or store. I think the same thing could be done at Norris whether Tennessee Valley Authority owned the power plant or not. I question whether it would be practicable at a navigation dam where the questions of time or slight differences of elevation are important. The Corps of Engineers operates locks for the purposes of navigation, and their agents are subject to the control of the War Department.

I know of at least three cases where the State of New York did not deem it advisable to allow a private company to operate a plant at a navigation dam. A license to a third party such as we have at Sacandaga would not be practicable at most places because if the Power Company should not obey my orders, I could close the gates in two minutes and take charge of the entire situation. From my understanding of the situation, a plant such as Wheeler or Pickwick could not operate with such a degree of facility.

The nature of the operation of the plant makes a difference, for example, if the plant were owned by the

Aluminum Company of America operating on bauxite, you couldn't go in and close it down instantaneously. However, if the plants were interconnected with a big hydro system, this could be done and the load absorbed at other plants. At Sacandaga, for example, we would not make such a lease with Henry Ford because we could not close the plant down without wrecking it instantaneously, whereas, if it is connected with a big hydro utility, we could close it down immediately. The difficulty would not be the physical difficulty of stopping the water but would be the fact that you would hesitate about wrecking the man's establishment. There is no difficulty of this sort at Sacandaga, and the operation of the dam is perfectly satisfactory so far as the public interest in the pool level, flood control, and navigation is concerned. The Hudson River Regulating District is not a private corporation for profit. It is a public corporation organized for water regulation, and it assumes no responsibility either directly or indirectly for the continuity of the flow of power out of the plant at Sacandaga. The lease to the power company is on a capacity basis, that is, it pays the board so much per kilowatt of capacity each month. The plant was built by the New York Power and Light Company. We simply lease the emplacements and the right to construct the plant. The New York Power and Light Company owned the site of the dam in fee simple. In short, we obtained the land for a nominal figure because of our agreement to lease the emplacements, otherwise we would have had to pay a large sum of money for the dam site. I was connected with the district at the time, and it was a matter of discretion as to whether we should condemn the land or make the lease. We have had no difficulty in the matter of control. (Counsel for the plaintiff here read in the title and citation of the Act under which the Hudson Regulating District was created.

It is Section 462, Chapter 647 of the Laws of 1911, entitled, "An Act Relating to Land, Forests, Waters, Parks, etc." as amended by Chapter 403 of the Laws of 1932, and Chapter 715 of the Laws of 1933).

Upon **Redirect Examination** the Witness Testified as Follows:

Sacandaga Reservoir is only 75 miles from tidewater. It would make a difference in the difficulty of unification and control if it were 650 miles as the Tennessee is from Knoxville to Paducah, or if there were long stretches of the river which prevent navigation for commercial purposes, or if it were necessary to construct other dams in these undeveloped stretches of the river. It would also make a difference if it were necessary to operate dams so as to control floods on another river such as the Mississippi. Bearing in mind the fact that the Tennessee Valley Authority is going to operate both the power plant at Wilson Dam and the one at Norris Dam, it would naturally be desirable to coordinate those operations under one control.

There are about 14 plants between Troy and Sacandaga and none below that point because it is tidewater.

Upon **Recross Examination** the Witness Testified as Follows:

In my previous statement that there would be some difference in unification, I had in mind navigation and flood control and also the question of power. For the routing of floods through the Tennessee, you would certainly want coordinated control. From a flood control standpoint, coordination would be difficult. If there was a coordinated control of all the plants, that would be one thing, but if there were a series of licenses for different companies at different places, that might make a differ-

ence in the coordination of the operation of those sites. The way I use the terms, that would imply a certain amount of independence in the coordinated units. The problem on the Tennessee is much more complicated than the problem on the Hudson and this was what I intended to convey by my answers on redirect examination. The great difficulty with a series of licenses is in enforcing the rules and regulations where a very limited time is involved and large quantities of flow to take care of.

COLONEL GLEN E. EDGERTON,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as follows:

I reside at Washington, D. C. and am a military engineer. My college training was received at the Agricultural College at Kansas, from which I graduated in mechanical engineering in 1904, and at the United States Military Academy, West Point, New York, where I graduated in 1908. Since that time I have been continuously an officer of the Corps of Engineers, and engaged almost continuously in the study or teaching or the practice of civil or military engineering. Among my assignments were included service on the construction of the Panama Canal, a period as Chief Engineer of the Alaska Road Commission, District Engineer at Jacksonville, Florida, Chief Engineer of the Federal Power Commission, teaching engineering at West Point, and District Engineer at Rock Island, Illinois. I am at present in charge of The River and Harbor Section of the Office of the Chief of Engineers. I have held this position for one and one-half years.

In the course of my experience, I have become familiar with river problems in the Mississippi and Tennessee Valleys. I have a general familiarity with a good many of the problems and a detailed knowledge of some, particularly

navigation and flood control problems. I have made some studies of those particular rivers.

I was District Engineer at Rock Island, in charge of extensive improvements on the upper Mississippi. My current assignment involves substantial contacts and supervision over parts of the operation of the development in the lower Mississippi. I have had some occasion to study the general problem in the Mississippi Valley for the Mississippi Valley Committee of the Public Works Administration and its successors.

A comprehensive program for navigation and flood control in the Tennessee River by stream flow regulation requires the use of certain natural reservoir sites for purposes of flood control. Storage sites which are desirable for flood control are usually desirable also for power development. There is a conflict between the use of storage for power and for flood control. For power purposes the reservoir is kept as nearly full as the demand for power will permit, whereas, for flood control the storage should be kept as nearly empty as the capacity of the down stream channels will permit. For a reservoir to serve for flood control and low flow regulation, I regard it as very desirable to set aside a definite and inviolable volume of storage for purposes of flood control. In the usual case that will decrease the value of the site for power development, or if the additional storage is added to the reservoir that would otherwise be provided for power development, the cost of the power development is increased. I have been referring particularly to headwater storage reservoirs, but my remarks apply generally to any power reservoir.

Any controlled development of the potential power sites upon the Tennessee River by private interests would doubtless produce a disconnected series of pools, which would leave stretches of the River unimproved for navigation. In

my opinion, the volume of storage represented by 1,500,000 feet set aside exclusively for flood control at Norris Dam is a very substantial volume.

I was with the Power Commission for one year as Assistant Chief Engineer, and for four years as Chief Engineer and I know of instances in which private development of reservoirs left intervening stretches which were defective for navigation purposes.

The uncontrolled operation of a headwater storage reservoir for power protection would introduce the conflict that I mentioned a short time ago, with respect to the use of the same or conflicting sites for flood control and power. It is not easy, if indeed practicable, to raise a dam already built a substantial amount. It makes it very difficult. As a consequence the occupancy of a reservoir site and the use of a large portion of its storage for power development would impede the subsequent development of the remaining storage available in the site for another purpose or for the same purpose.

The interference with navigation by private development of sites in headwaters would be largely limited to that which might be produced by peak operation of power storage in such a way as to create alternating periods of high and low water in the navigable section. This interference would be less with high dams in the main stream of the type being constructed by Tennessee Valley Authority than with the alternative low dams. The high dams will relieve to some degree the necessity of the regulation of headwater releases in low flow periods. In my opinion, it is not practicable to procure a completely unified development on the Tennessee River for the purposes of navigation and flood control upon the Tennessee and the reduction of flood waters upon the Mississippi by means of private development.

If provision were not made in the building of navigation and flood control dams for later development of power, the later power development on the river would be more difficult and more expensive. Any subsequent development of power by private interests would be interfered with, and perhaps prevented by the conflicts which I have heretofore indicated. Later private power development under restrictions imposed under the authority of the Federal Water Power Act would be discouraged by the restrictions to a degree dependent upon the magnitude and effect of the restrictions in particular cases.

Operation of the series of dams on the main stream of the Tennessee and its tributaries to secure maximum benefit to navigation on the Tennessee and flood reduction in the Tennessee and Mississippi Valleys would require a coordinated day to day manipulation of the various dams and reservoirs. I do not know of any development of a complete river system by the erection of projects by private interests that is comparable in magnitude or multiplicity of features to the proposed development of the Tennessee River for navigation, flood control, and power purposes. If I were instructed to improve navigation on the Tennessee River, to reduce the destructive flood waters in the Tennessee Valley and in the Mississippi Valley by works in the Tennessee Valley, I would consider it necessary to provide storage on the tributaries by dams such as Norris, and high dams on the main river such as Wheeler and Pickwick to accomplish those purposes. (The witness here identified a publication entitled, "No. 3 Report of the Water Planning Committee.")

This is the report of the Water Planning Committee of The Water Resources Section of The National Resources Board. It is the report of December First and

seems to be a complete copy of the same document that has been furnished to me as an official. I represented General Markham at a large number of the meetings of the committee.

Upon **Cross-examination** the Witness Testified as Follows:

I am rather familiar with House Document No. 328 and have a good general knowledge of the Jadwin Report. I am in general concurrence with the recommendations adopted by the River and Harbors Act of 1930. I have not been advised by the Tennessee Valley Authority as to the details of its proposed development or power program. I have in mind the general development outlined in House Document No. 328 and the general developments that are indicated in the testimony that I have heard at the trial. When I state that I know of no comparable development, I am assuming a complete series of dams to effectuate navigation, and I intended to include a unified system of navigation, flood control, and power development.

My understanding from conversations with officials of the Tennessee Valley Authority is that the program has not been outlined with any great precision beyond the works under construction. My answer was based on future development which would be practicable, complete, and comprehensive, and my answer would be correct whether or not power was included. I know of no private development for the purposes of flood control and navigation elsewhere as the result of grants and conditions imposed by the United States Government. I am not familiar with licenses granted to the Alabama Power Company for developments on the Tallapoosa and Coosa Rivers. I know of licenses which have been granted with

conditions imposed that included the construction of locks and provisions to supplement low stages of the river below. I am also acquainted in a general way with the leases by the United States of power site emplacements on the recent dams on the Kanawha River. I know that such leases are made reserving control and manipulation of the water to public authority. The power plants on the Kanawha have not been built as yet. The locks and pool are operated by the Corps of Engineers to whom is reserved complete control for purposes of navigation and flood control. A person operating a power plant must take it in accordance with conditions laid down in the license. So far as I know, the reserved right to manipulate the waters is absolute so far as the requirements of navigation are concerned. I do not know whether any question of embarrassment or interference to the United States for the purpose of navigation or flood control has arisen out of the operation of the dam at Cherokee Bluff or on the Tallapoosa or Coosa.

I have what is known as the River and Harbor desk in the office of the Chief of Engineers and problems of that sort would undoubtedly be passed on by my section. It is probable, however, that even a matter of substantial magnitude might be attended to in my absence. I have encountered none of these problems.

The Corps of Engineers has not been consulted or advised with reference to Pickwick or Wheeler Dams to my knowledge. The design of Wheeler or Pickwick Dams has never come over my desk for approval, but such a matter would not ordinarily come to me. It would go to the Miscellaneous Civil Section. I do not know of any such approval being given.

So far as I know, the Tennessee Valley Authority's power program has not been taken up with the Corps

of Engineers nor has the Corps of Engineers been consulted with reference to it.

I regard it as necessary to use a given volume of storage for flood control which must be reserved exclusively for flood control.

In the so-called storage capacity there is a possible conflict in interest between navigation and flood control. For flood control that capacity should always be kept empty until the flood is threatened, and for navigation it is kept full for low water stages. It should also be kept full for power. I can conceive that there might be substantial conflict in the operation of a storage dam between flood control on the Tennessee and flood control on the Mississippi.

The Tennessee Valley Authority has not submitted to me any standard or rules as to the operating curve of the Norris pool and they have not indicated to me what would be the controlling motives in the manipulation of the pool, nor as to whether they particularly desire flood control at Chattanooga or on the Mississippi.

I have a general knowledge of the history of storage reservoirs on the upper Mississippi. I think about seven reservoirs with a total storage capacity of about 2,000,000 acre feet are operating in particular places for the purpose of building up the low flow of the upper Mississippi for navigation and other purposes. This method of control was not abandoned, but they are now building locks and dams on different projects for which that regulation would have been inadequate without locks and dams in any event.

No ordinary program of headwater release would materially affect navigation in the high dam pools of the Tennessee River. (At this point counsel for the plaintiffs read from plaintiffs' exhibit No. 55, Sections 81 to 95

on pages 30 to 33, an excerpt which was in substance as follows: The reservoir theory is ideal when it fits the expectation to hold the water where it falls, on comparative cheap land. It is not always feasible because sites and cheap land are not always available where the bulk of the rain falls. The principle is sound within its field of application).

Because of its size, the Mississippi constitutes a different problem from that of any other river that has been considered. It has been found that by constructing 203 headwater reservoirs at a cost of about $1,300,000,000, and by operating those reservoirs primarily for Mississippi River control, it would be possible to produce a dependable reduction in stages on the river of about six feet at Cairo, seven feet at the mouth of the Arkansas, and five and four-tenths feet at the mouth of the Red River. The value of local benefits is placed at about $150,000,000, leaving a net cost of $1,150,000,000 chargeable to the control of floods in the alluvial valley. These reservoirs would afford inadequate relief at a cost of four times as great as the cost of the plan for complete protection proposed herein by means of levees.

If these reservoirs should be operated primarily for other purposes such as power, local flood control, irrigation, etc., they would produce a reduction in gauge heights of less than one foot in the alluvial valley. The reservoir sites have a potential economic value to the localities in which they are situated. It is not economically sound to subordinate this asset to the protection of a distant region.

Reservoirs near the valley can be operated more effectively than head water reservoirs. A system of 30 such reservoirs was studied. They would produce a dependable reduction in stages on the river for about half the

cost of head water reservoirs, but they will not completely solve the problem and will be much more expensive than the complete project recommended.

Investigation of proposed reservoirs at the mouths of several of the tributaries shows that in general they could be depended upon to reduce stages during floods by little in excess of the reduction effected by the reservoir capacity afforded under present conditions. The cost of securing this small additional effect would be far in excess of the cost of attaining the same protection by the plan recommended.

The chief reason that reservoirs do not prove feasible are that the flows of the Mississippi are so great and the flood stages last so long that a very large amount of reservoir capacity has relatively small effect. It will take at least 7,000,000 acre feet in valley and 11,000,000 acre feet in head water storage to reduce gauge heights one foot at Arkansas City.

If an attempt be made to use the reservoir capacity with rules of operation aiming at more efficient results greater effect may be obtained some years, but there is danger that a flood larger than expected will fill the reservoirs before the flood crest is passed. In this respect reservoirs are not as safe as flood channels which operate automatically and increase in efficiency with increase in flood flows.

Such aid as may be hoped for from reservoirs can be secured economically only by gradual processes. It is hoped that reservoirs constructed primarily for local purposes will withhold flood waters and thus aid Mississippi control by affording an additional factor of safety. In most cases the benefits for power or local flood control are of greater value than benefits resulting from the use of reservoirs for flood control. On the Mississippi such reservoirs as are built would therefore probably be used

primarily for benefits on the tributaries and in that case their effect on lower Mississippi floods would be much smaller than if they were used exclusively for the latter purpose. They will, however, when constructed, provide an additional factor of safety to the lower Mississippi.

I have no adequate information to warrant either an agreement or disagreement with that statement. So far as I know, there has been no departure or modification of this opinion by the Corps of Engineers.

Upon **Redirect Examination** the Witness Testified as Follows:

There have been recent studies by the Mississippi River Commission in relation to the general problems here discussed. These studies do not contemplate scrapping of the levee system. I do not know what the recommendations are except from the testimony I have heard here. I assume that reservoirs would be used to supplement the levee system since the main levee system is already substantially completed.

The dam under construction on the Kanawha River is not designed and proposed for use for flood control purposes. If that problem were involved, you would be faced with additional requirements and further restrictions.

The direct method of appropriating the money and developing the Tennessee River for navigation and flood control purposes by the United States Government the most expeditious method of obtaining that development.

Upon **Recross Examination** the Witness Testified as Follows:

In my answer as to the availability of high or low dams, I was not asked to give any consideration to the element of cost or relative benefits or as to whether or not the high

dams would justify the greater cost. I was speaking with regard to the physical attributes from a navigation standpoint. A nine-foot channel of the low dam type throughout the Tennessee to Knoxville would give a good navigation channel with less expense. The elevation of the Kanawha Dams is something like twenty-six feet. I do not recall exactly.

JAMES S. BOWMAN,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as Follows:

I am a civil and hydraulic engineer. I began engineering work about 1905 and worked in various subordinate positions, on drainage and railroad location construction until 1910. In 1913, I graduated from the State University of Iowa in Civil Engineering. For four years, I was with the Miami Conservancy District at Dayton, Ohio, on studies and designs for flood control work. During 1919, I was Irrigation Engineer for Joseph Leiter in Wyoming. From 1920 to 1928, I was hydraulic and supervising engineer for the Fargo Engineering Company at Jackson, Michigan, in charge of hydraulic studies for almost every type of hydraulic practice, including flood control, river work, power development, and sanitary work. From 1928 to 1932, I was engaged in General Hydraulic Engineering practice with the Fargo Engineering Company at Chicago in charge of hydraulic investigations and reports. In 1932 and 1933, I taught hydraulic engineering at the University of Wisconsin, teaching hydrology, river hydraulics, and navigation, water power and hydraulic machinery. Since October, 1933, I have been with the Tennessee Valley Authority as principal hydraulic engineer in charge of engineering investigations.

During an average year, the stream flow variations on the Tennessee will be from somewhere between 7,000 and 8,000 second feet up to 300,000 or 350,000 second feet. This wide range in stream flow has a serious effect on navigation in the River. During low water, there are a great many bars and obstructions which seriously interfere with navigation. In stages of about 100,000 second feet, navigation conditions are fair but of course the duration of this is short. In the Sheffield Cut and past Tuscumbia Bar and Pride's Island the low water depths get down to four or four and one-half feet and this makes low water navigation difficult in this stretch of the river between Colbert Shoals and Florence. Navigation is likewise difficult in the stretch above the head of Wilson Dam pool to Decatur; up to Widow's Bar it is somewhat less difficult, and from Chattanooga to Knoxville on what is known as the upper river, there is practically no navigation for commercial craft at low water. The extreme floods present problems at other seasons. It is not safe to operate small barges which are used in low water in flood stages and tow boats do not have sufficient power.

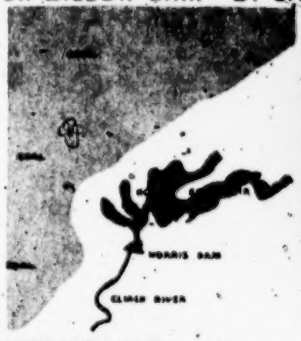
There is occasionally extensive damage by actual flood conditions to transportation facilities, etc. About the only method of regulating floods in the Tennessee Valley is by means of storage. For navigation, slack water of some sort seems to be about the best and only solution. Norris Dam is a project which would be useful in these respects. (The witness here identified a chart entitled, "Effect of Norris Dam on Tennessee River Channel Depths and on Wilson Dam." This was introduced in evidence as Defense Exhibit No. 35, a reproduction of which appears upon the opposite page.)

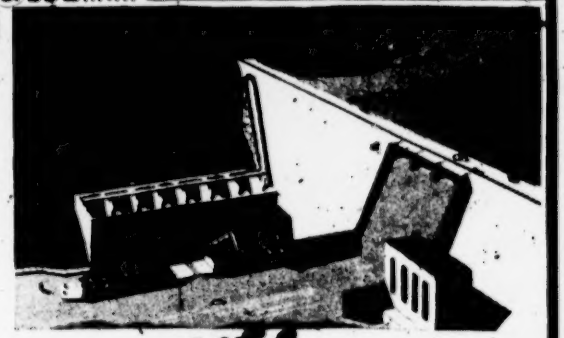
At Norris Dam, there is available for low water regulation 1,500,000 acre feet of storage. It is proposed to lease

Defense Exhibit No. 35.

EFFECT OF NORRIS DAM ON TENNESSEE RIVER CHANNEL DEPTHS AND ON WILSON DAM - BY J. S. BOWMAN

NORRIS DAM EFFECT ON CHANNEL DEPTHS
PICKWICK TO MOUTH
EXISTING 4.5 FT
WITH NORRIS 6 FT





ACRE FEET OF STORAGE NORRIS DAM
FOR FLOOD CONTROL 1,400,000.
FOR LOW WATER REGULATION 1,500,000.

PADUCAH

4.5
6

NORRIS DAM

KNOXVILLE

2.7

WILSON DAM CONTINOUS POWER
WITHOUT NORRIS OR INTER-TIE 55,000 KW
WITH NORRIS REGULATION ONLY & WITHOUT INTER-TIE 90,000 KW
WITH NORRIS & WITH PROPOSED INTER-TIE 163,000 KW

PICKWICK LANDING

4.5
9

7
9

7
9

9
9

WHEELER DAM

WILSON DAM

3
9

3
4.8

HALES BAR DAM

4.5
4.5

WIDOWS BAR DAM

CHATTANOOGA

GUNTERSVILLE

EXISTING CHANNEL DEPTHS

CHANNEL DEPTHS WHEN NORRIS IS COMPLETED

POOL DEPTHS WHEN PICKWICK AND WHEELER DAMS ARE COMPLETED.

UPPER FIGURE DENOTES EXISTING DEPTHS
LOWER FIGURE DENOTES DEPTHS WHEN 3 ABOVE DAMS ARE COMPLETED

NOTE: This exhibit shows the capacity of Norris Dam for flood control, its effect on channel improvement on the Tennessee River; also the effect on U. S. properties at Muscle Shoals; also the back-up of the Clinch River.

Data were obtained from surveys by the Army Engineers and T. V. A. and from stream flow records of the U. S. Geological Survey.

Existing minimum navigable depths are shown by the upper figures along the river and indicated by the relative weight of the heavy line. Except within the limits of the pools above Pickwick and Wheeler Dams, the lower figures show the minimum depths at low water after regulation by Norris Dam and the comparative increase in low water depth by the light line.

The storage available at Norris Dam for flood control and the effect of low water regulation at Wilson Dam are presented in various notes.

this storage which has accumulated during the period of high flow on the Clinch and Powell Rivers during the period when the flow on the Tennessee is at a low point. Between Chattanooga and the mouth of the Clinch River, the present low water depth of one foot will be increased to 2.7 feet. The increases shown on the chart are somewhat less than given by Mr. Barker. His testimony shows what it is possible to obtain by these releases, and these depths have been arbitrarily reduced from one-half to .7 of a foot to allow for irregularities in operation, and to put matters on the most conservative basis. From Widow's Bar to Guntersville, the low water depth will be increased from three feet to 4.8 feet. Within the limits of Wheeler pool, the low water depths will be increased from three to nine feet. In Wilson pool we now have a minimum of nine feet. In the Pickwick pool, the present minimum depth of four and one-half feet will be increased to nine feet.

At Big Ben Shoals we now have a minimum depth of about four and one-half feet which will be increased to six feet. In general we will have a minimum depth around seven feet during a large part of the year between Pickwick Landing and Paducah.

At the present time we can obtain from the natural stream flow at Wilson 50,000 KW for continuous use. The release of water from the Norris storage for low water regulation will increase this power at Wilson from 50,000 KW continuous to about 90,000 KW continuous. With some inter-tie between Norris and Wilson so that they can function essentially as a system, the continuous power at the two plants would be 163,000 KW.

At Norris Dam, there is a distinct allocation of 1,400,000 acre feet for flood control purposes. That surcharge starts at elevation 1020 which is the top of the storage for low water regulation. The possible limit is 1052 feet which is the upper limit of any conceivable flood that might occur

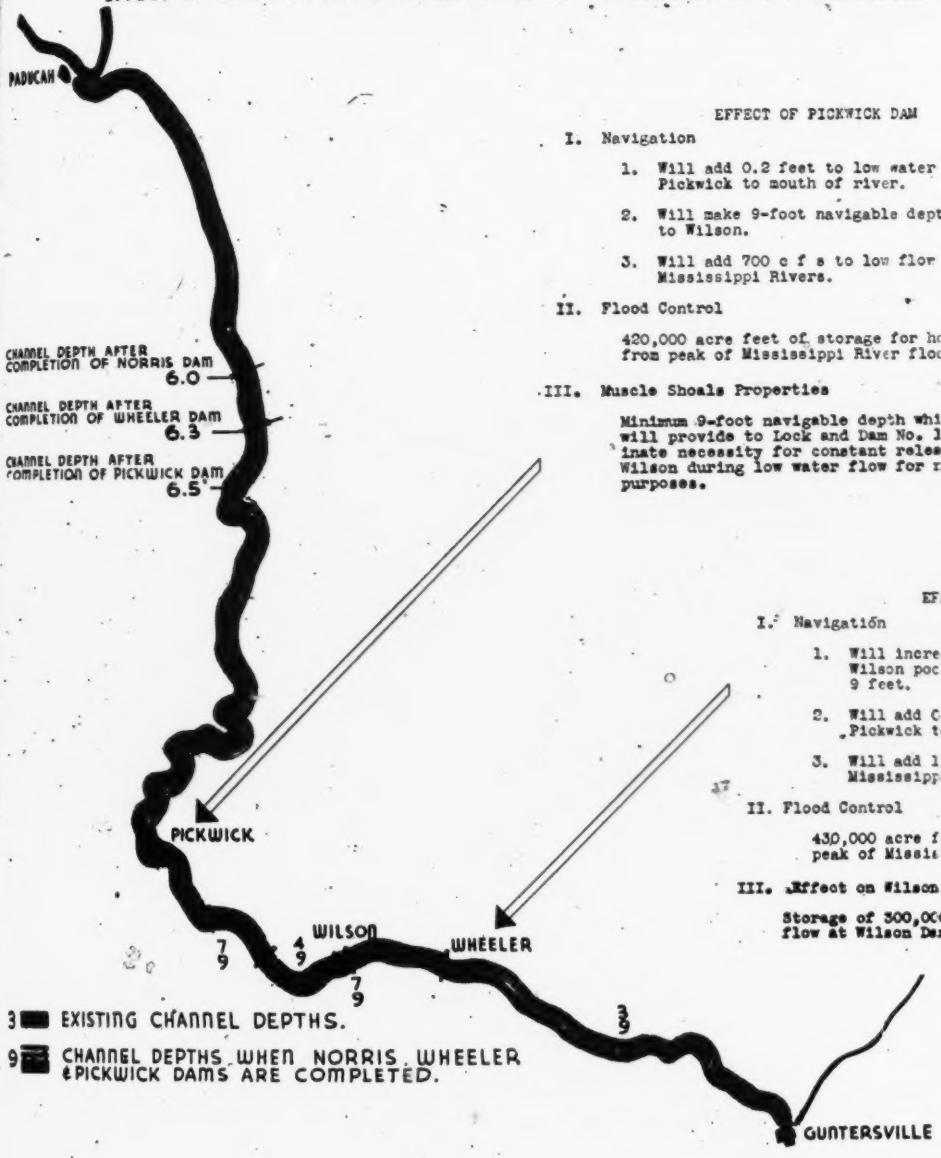
and which conceivably could be held in the reservoir. The generators will be loaded up to their full rated capacity at a 165 foot head. Elevation 1020 which is the top of the low water storage, gives a head of 194 feet so the generators are fully loaded at considerably less than the top. This gives additional space which can be drawn down without affecting the output of the generators. This flood value of Norris will of course be of material aid all down the river and will have some effect on the Ohio and the Mississippi. (At this point the witness identified a chart entitled "The Effect of Pickwick and Wheeler Dams on the Tennessee River Channel Depths and on Wilson Dam, Basic Data by J. S. Bowman." The chart was introduced in evidence as Defense Exhibit No. 36, a reproduction of which appears upon the opposite page.)

Wheeler Dam will increase the minimum navigable depths of the river from the head of Wilson pool to Guntersville from three to nine feet. It will add .3 of a foot to the navigable depth from Pickwick to Paducah due to the release of low water storage from the Wheeler pool. During extreme low flows this release of about 300,000 acre feet will add 1,000 c.f.s. to the flow of the river below Pickwick and, of course, this will reach the other streams to which the Tennessee is a tributary flattening somewhat as it goes down. From a point five feet below the normal pool level to a point three feet above the normal pool level 430,000 acre feet will be available for flood control to hold the flow from the peaks of Mississippi River floods. The release of 300,000 acre feet from Wheeler in low water times will make more valuable the government investment at Wilson Dam.

Pickwick Dam will add .2 of a foot to the navigable depth below Pickwick and will give a nine-foot navigable depth from Pickwick to Wilson. In low water it will add 700 c.f.s. to the flow of the river below Pickwick. Approxi-

Defense Exhibit No. 36.

EFFECT OF PICKWICK AND WHEELER DAMS ON TENNESSEE RIVER CHANNEL DEPTHS AND ON WILSON DAM - BASIC DATA BY J. S. BOWMAN



EFFECT OF PICKWICK DAM

I. Navigation

1. Will add 0.2 feet to low water depth from Pickwick to mouth of river.
2. Will make 9-foot navigable depth, Pickwick to Wilson.
3. Will add 700 c f s to low flow of Ohio and Mississippi Rivers.

II. Flood Control

420,000 acre feet of storage for holding flow from peak of Mississippi River floods.

III. Muscle Shoals Properties

Minimum 9-foot navigable depth which Pickwick will provide to Lock and Dam No. 1 will eliminate necessity for constant release of water at Wilson during low water flow for navigation purposes.

EFFECT OF WHEELER DAM

I. Navigation

1. Will increase minimum depth from head of Wilson pool to Guntersville from 3 feet to 9 feet.
2. Will add 0.3 feet to low water depth from Pickwick to mouth of river.
3. Will add 1,000 c f s to low flow of Ohio and Mississippi Rivers.

II. Flood Control

430,000 acre feet of storage for holding flow from peak of Mississippi River floods.

III. Effect on Wilson Dam

Storage of 300,000 acre feet will increase low flow at Wilson Dam.

NOTE: This exhibit shows the effect of Pickwick and Wheeler Dams for channel improvement on the Tennessee River from Paducah to Guntersville, a distance of 388 miles; also the effect on U. S. properties at Muscle Shoals.

Downstream below Pickwick, the minimum navigable depth at low water is shown as with stream flow regulation from Norris Dam. The total depths with regulation by Wheeler and Pickwick Dams in addition to that by Norris are also shown.

Upstream from Pickwick and Wheeler Dams, the existing minimum navigable depths are shown by the upper figures. Lower figures (9 ft. in each case) show the minimum navigable depths which will be equalled or exceeded after these dams have been completed.

The effect on the Muscle Shoals properties is shown in the notes for each dam.

mately 420,000 acre feet of storage is available for flood control by holding the flow from the peak of Mississippi River floods. The providing of a nine foot navigable depth back to Lock and Dam No. 1 below Wilson will make it possible to operate Wilson at peak during low water flows. This is not now possible because the Corps of Engineers restricts the use of the river flow when it gets as low as 12,300 c.f.s. If the dam is operating on a 50% load factor it must waste approximately one-half the water at low season.

Wilson dam has not been operated in the past at a degree of efficiency comparable with its potentialities. There was not only lack of water in the low season due to the irregularity of the flow, but there was also difficulty with navigation below Wilson so that in spite of the installed capacity of 184,000 KW, only about 55,000 can be produced on peak in the summer time and during certain periods of the night, we cannot generate up to 55,000 and simply have to spill the water. Were it not for the interference with navigation below Wilson, we could peak the flow and get a 100,000 peak and use all the low water flow. Navigation, of course, is given the preference. This handicap is not due to any method of construction or design of the Wilson plant itself. It is a matter of the control of the flow of the water in order to operate efficiently. The different projects which I have described will substantially improve the efficiency of those properties. Norris Dam through the release of waters stored during the high flow season will increase the possible continuous power at Wilson from 50,000 to 90,000 KW simply by releases during low water season and without the generation of any power at Norris. Wheeler Dam has about 300,000 acre feet of storage which can be released during a low water season without handicapping navigation at all in the Wheeler pool. This will give an additional flow of 1,000 c.f.s. during the low water season and will

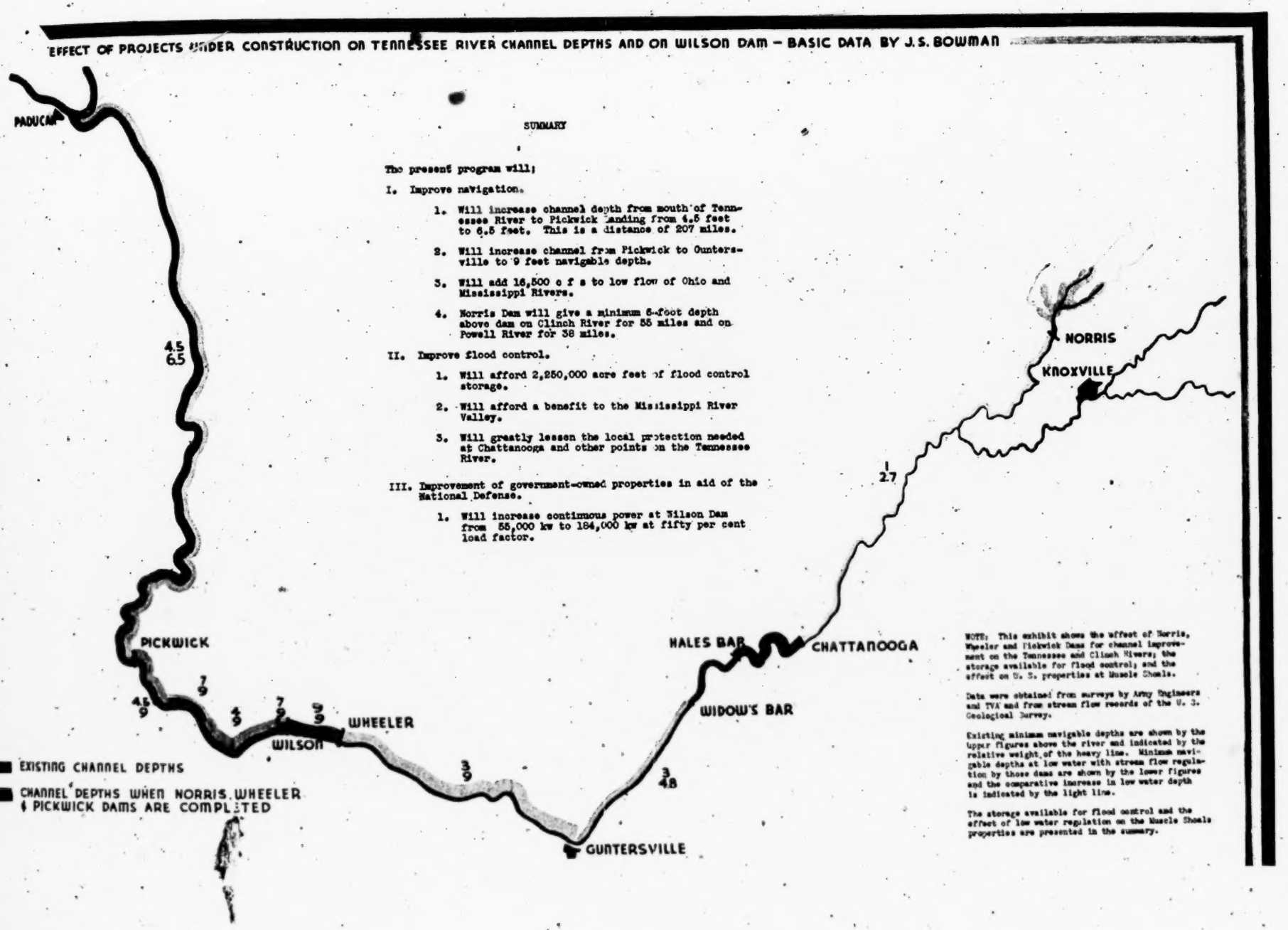
produce at Wilson Dam approximately 7,000 KW. The secondary power available during the high water season will be converted to primary power by release of this water during the low water season so it adds 7,000 KW continuous power at Wilson Dam. Norris, Wheeler and Pickwick will each make a substantial contribution to the value of the Wilson Dam properties.

At the present time the minimum continuous power at Wilson Dam is about 50,000. By use of the pool at Wilson if it is full at the time the low water season arrives, this might be increased to 55,000 but this is not a certainty so we take 50,000 as a base. The maximum which should be produced at Wilson is limited by the capacity of the plant, that is, 184,000 KW. There are eight generators at Wilson Dam. The first four were installed in 1925 and the second four the following year. They were all installed prior to the commencement of the Tennessee Valley Authority operations.

Two generators are planned for Norris and one for Wheeler. No others are planned. That is no definite arrangements or commitments have been made for installing additional generators or generating units. Of course, the possibility has been investigated in the course of our general investigations of the properties which we are developing, but present plans call for an increase of only three in the total number of generators, that is, from eight to 11.

With the regulation of stream flow by Norris, the continuous power at Wilson can be raised to 90,000 KW. With the inter-tie between Wilson and Norris 163,000 KW continuous will be available. (At this point the witness identified a chart entitled, "Effect of Projects under Construction on Tennessee River Channel Depths and on Wilson Dam." This chart was introduced in evidence as Defense Exhibit No. 37, a reproduction of which appears upon the opposite page.)

Defense Exhibit No. 37.



SUMMARY

The present program will:

I. Improve navigation.

1. Will increase channel depth from mouth of Tennessee River to Pickwick Landing from 4.5 feet to 6.5 feet. This is a distance of 207 miles.
2. Will increase channel from Pickwick to Guntersville to 9 feet navigable depth.
3. Will add 16,500 c f s to low flow of Ohio and Mississippi Rivers.
4. Norris Dam will give a minimum 6-foot depth above dam on Clinch River for 55 miles and on Powell River for 38 miles.

II. Improve flood control.

1. Will afford 2,250,000 acre feet of flood control storage.
2. Will afford a benefit to the Mississippi River Valley.
3. Will greatly lessen the local protection needed at Chattanooga and other points on the Tennessee River.

III. Improvement of government-owned properties in aid of the National Defense.

1. Will increase continuous power at Wilson Dam from 55,000 kw to 184,000 kw at fifty per cent load factor.

NOTE: This exhibit shows the effect of Norris, Wheeler and Pickwick Dams for channel improvement on the Tennessee and Clinch Rivers; the storage available for flood control; and the effect on U. S. properties at Muscle Shoals.

Data were obtained from surveys by Army Engineers and TVA and from stream flow records of the U. S. Geological Survey.

Existing minimum navigable depths are shown by the upper figures above the river and indicated by the relative weight of the heavy line. Minimum navigable depths at low water with stream flow regulation by those dams are shown by the lower figures and the comparative increase in low water depth is indicated by the light line.

The storage available for flood control and the effect of low water regulation on the Muscle Shoals properties are presented in the summary.

These projects would increase the low water possibilities of output at Wilson from 50,000 to 97,000 KW. That 97,000 KW could not be produced, however, without Pickwick which would afford a nine foot navigable depth without releases from Wilson. Without Pickwick we could peak from 97,000 to 102,000 KW only before we would run into the restriction of the Corps of Engineers in order to maintain four and one-half foot navigation below Wilson. With this restriction removed, we could get the full benefit of the peak capacity at Wilson which is 184,000 KW and having 97,000 continuous power available from Wilson and Wheeler low water flow regulation we can roughly say that Wilson can be used to full capacity on a 50% load factor after these 3 plants are completed.

After the completion of these plants including the two generators at Norris and one at Wheeler, the total continuous power available on the three dam system will be 202,000 KW. This will be the total from all projects now under construction or definitely planned.

Assuming a 50% load factor, Norris regulation will give 180,000 KW of primary power available without the inter-tie. The firm figure at Wilson after the regulatory benefits of Norris, Wheeler, and Pickwick is 97,000 KW.

Each of the projects under construction will contribute substantially to the improvement of navigation on the Tennessee River; the reduction of destructive flood waters in the Tennessee River basin and the Mississippi River basin and in the improvement of the existing government owned properties at Wilson Dam.

There are inconsistencies in the operation of dams required to serve the multiple purposes of navigation, flood control, power and the improvement of the government owned properties at Wilson Dam. The conflict usually arises from an attempt to use the same storage capacity

for two different purposes which are antagonistic. If we attempt to store water for low water regulation and for high water regulation in the same place, and no provision is definitely made for the separation of the volume of the water or separation as to seasonal use of such space, sooner or later we run into the situation where there is too much or too little of one or the other.

If we assume that floods are coming about the middle of March and hold our reservoir low until after the flood season is over, then in dry weather we can't fill up the reservoir in order to have the water to use for low water regulation. On the other hand, if we are trying to effect low water regulation and fill up the reservoir before we are sure that the floods are over, a flood might occur when the reservoir level is high and very little flood storage space is available.

Normal pool level is the top of the storage space or the pool level which would ordinarily be used for low water regulation. We do not contemplate storing any water above that level for the purpose of low water regulation. Everything above that level will be reserved for flood control storage. Above that is the so-called surcharge space. The amount of volume which we have below the canal pool level for use for low water regulation is the draw-down.

At Norris Dam 32 feet is definitely allotted to surcharge only. Of course, it could go higher than that, in fact all the way to the roadway, and if it went that high it would retain a tremendous amount of water in the reservoir. In addition to the surcharge space and the space above the surcharge we have room for a draw-down. The draw-down which would be used in any year for supplementing the low water flow of the river is 58 feet from elevation 1020 down to elevation 962. We can draw-down still lower

if we have a year which is lower than any yet recorded. In an ordinary season after we have drawn the water down to the lowest contemplated stage we would expect at Norris not much more than enough water to fill it back to the permanent crest. It would not fill above elevation 1020 with the water available, assuming that you always have to release some from Norris for the purpose of sanitation and the preservation of riparian rights. In other words, we customarily would have a vast amount of flood storage at Norris. At Norris the reservoir is so large and so close to the drainage area that in the case of very heavy precipitation we could not draw-down. The draw-down must be made during the low water season and kept until the floods are over. This applies to the low water storage space.

Main river dams can be and will be operated to a considerable extent in the same manner as Norris. That is, there is five feet below the normal pool level which can be drawn down for low water regulation. It should be kept at that low level from the end of the low water season until the flood season has passed. This does not handicap power operations to any extent at all because there is sufficient flow in the river during the winter and spring so that storage for low water regulation is not required.

I can see no reason why anyone should want to fill up the surcharge and keep it full even if the dam should be operated for power to the fullest possible extent. If the surcharge is kept full there is no space in which to get pressure when the flow has dropped off. By using the surcharge as I have described it, it is possible to get more value for power production so I can't see where there is any conflict between surcharge and navigation or power. If I were operating those plants to get the maximum power production, I would want to work those surcharge

operations for flood control because that simply means that you catch high water and you can use it in low water seasons. So far as I have anything to say in recommending the layout of a project for any particular purpose I have given primary consideration to the preservation of navigation and flood control facilities first. So far as I know there are no official plans or regulations as to the operation of the dams. In case of an unusual drought the conflict may arise between navigation and power during low flow periods of the year when it might be desirable for the production of power to release so much water that the pool would be drawn down below the minimum navigation level.

On the main river dams under proper operation and coordination of the operations there should be no conflict between flood control and power. By reducing the peak as we get down the river tail water head is decreased below the various plants and more head thereby obtained. If the floods are reduced there will not be as much back water against the plant and I do not see that there is a conflict. Although they might be operated so that there would be a conflict, I think they could be operated to secure the maximum efficiency for both purposes.

I see no reason why in a coordinated private operation of the scheme there should be a conflict. However, it would take a very close reconciliation of interests to eliminate those conflicts so there would not be antagonism. It seems to me that in any private development, or partially private development, there would be antagonism not only from the standpoint of operation itself in adjusting the flows in all these projects to secure the greatest benefit, but there would also be considerable conflict due to the fact that private interests probably would not be entirely reconciled to increasing their investment to provide for

making the multiple purposes entirely effective. I can see very clearly the probability of conflict if different private interests developed different sites for independent undertakings. The type of operation which would control such a complete system as distinguished from individual units would require day to day and perhaps hour to hour manipulation and the coordination of all the units of such a system. That would require a careful organization plan and the prediction in advance of flood stages both on the tributaries and on the lower river. On the Mississippi and the Ohio it would be necessary to get all these predictions into a "message center" where they would have to be analyzed very quickly and enforceable instructions sent out from this center regulating the operation of the pools. This would require a very thorough organization with power to enforce its regulations. It would have to be moving on the instant almost with the precision of a military organization to accomplish the results. There is a problem of reconciling conflicts between divers private interests. With a system of private development one or two dams might be built and the plan of operation would be prepared with a view of securing for them the greatest benefit and the Federal Power Commission would set up regulations on this basis. If another plant is built in another section of the river, its requirements might be entirely different and satisfactory arrangements could not be made without interfering with the regulations set up for the first plants. This interference would occur at each stage of the development making it very difficult for private interests to go in there without feeling that they were handicapped. Considering all the difficulties in the way of promoting and financing, the time which might be required for its completion, and changing conditions, I do not believe that it would be practicable for any one private

interest to go in and accomplish a complete project such as would be necessary for navigation on the Tennessee River and flood control in the Tennessee and Mississippi River basins. I am, in general, familiar with the permits of the Federal Power Commission as applied to the Tennessee River basin and I do not know of any permit that has ever been issued to cover any system of that kind or comparable with this one. Since the passage of the River and Harbors Act of 1930 none of the alternative high dam sites on the Tennessee River have been finally licensed or definitely undertaken by a private company. (At this point Counsel read into the record a portion of an official report from the Secretary of War to Congress, House Document 131, 72d Congress, 1st Session, including a letter from Colonel George R. Spaulding, Division Engineer, Upper Mississippi Valley Division, dated August 13, 1931, on the subject, "Interim Report Required under Provisions of Rivers and Harbors Act of July 3, 1930." This report was in substance as follows:

This report covers the prospective cooperation offered by responsible interests under the Rivers and Harbors Act. On September 6, 1930, the District Engineer at Chattanooga addressed 786 inquiries to prospective corporations, public officials, power companies, and others. Seventy-two replies were received indicating interest but no firm offer of prospective cooperation. On July 14, 1931, letters of inquiry were addressed to these 72 and seven replies were received expressing continued interest. In addition to this, the District Engineer has had personal conferences and reports some interest but no immediate prospect of definite cooperation. The District Engineer concluded that there is no immediate prospect of important cooperation. In 1929 a preliminary permit was issued to the Mississippi Power Company in the stretch of the river between Dam

Number 1 and Pickwick Landing. Investigations were made but no offers were made of cooperation. The Southern Industries and Utilities, Inc., has applied for a preliminary permit in the vicinity of Aurora Landing. This corporation may be considered as offering possible prospective cooperation. The Company has as yet made no definite plans and we may consider it as a tentative offer depending on further developments as to engineering feasibility, and economical possibilities. "I, therefore, report that as yet there has been no firm offer of cooperation by responsible interests to construct a high (power-navigation) dam as substitute for two or more of the low (navigation) dams recommended in the adopted project.")

So far as I know there has been no substantial progress beyond the stage therein described since the date of that letter.

We made extensive studies covering the proper location of Pickwick dam, that is, considering its location in that general vicinity. Considering power output alone we could perhaps produce energy a little more cheaply at Parkers Landing but for navigation purposes, a low navigation dam would have been required in the vicinity of Pickwick Landing, if the high dam were built at Parkers Landing, in order to back water to Parkers Landing either with Aurora Dam built or with the natural channel conditions below Pickwick. Considering the fact that the government would have to build both of these dams, it was more economical to build the high dam at Pickwick Landing and accomplish adequate navigation on the entire stretch rather than to put in one low dam and one high dam. If a private company had been developing the high dam they would naturally have built that at the most economical point.

We selected the general locality in which Pickwick is being constructed because from the head of Colbert Shoals

to the entrance of Lock and Dam No. 1 just below Wilson is the worst stretch in the lower river, after the head of Muscle Shoals and the Elk River Shoals has been improved by the construction of Wheeler Dam. Naturally we were anxious to eliminate the bottle-neck near the lower end of the river, that is, pick the worst stretches first and improve them so that craft could use the other minimum depths which existed elsewhere after the improvement of the worst section. Our purpose has been to pick out first the particularly bad stretches for improvement in order to make possible the general improvement of a particular stretch of the river especially at the lower end. It would do no good to construct improvements above Chattanooga with the bad places existing below, but after Pickwick, Wheeler and Norris are constructed they will afford six and one-half foot minimum navigable depth into Chattanooga. Developments above that point would come later.

There is a lot of potential traffic in the area below Chattanooga. Florence has always been more or less a railroad and highway center, and we are continually working up toward still greater industrial areas, that is, past Decatur and Guntersville and ultimately towards Chattanooga which is one of the main centers of the valley so far as traffic facilities and industries are concerned. If I were particularly interested in power I probably would have picked out the Wheeler site first for various reasons. I do not know whether I would have chosen Pickwick or not. If I had been looking for the most economical site as distinguished from the greatest quantity of power, I would have changed the location of the present site of Pickwick dam. I would not have attempted to build such a high dam.

If a series of 32 low dams were built in the main river, the subsequent construction of high dams would necessitate the replacing or drowning out of each of the existing

low dams. There is no way of salvaging the value of the investments in those low dams. The foundation built for a low dam would not be deep enough for a high dam and it would probably be uneconomical to go in and put in such deep foundations at some of the low dams. They would be of no particular use if you built a system of high dams later, and they might be a handicap as portions of them might have to be removed before the full depth could be secured over that section. It is conceivable that if they were at just the right locations, part of them could be used for coffer-dams in building high dams, but I believe it would be necessary to duplicate the entire project. The construction of each of the seven high dams covered by House Document No. 328 would involve the elimination of at least two or three low dams. If a system of high dams should be constructed without providing for the possible future installation of generating facilities, and the power project were later installed, it would mean a duplication of investment. The latter development would interfere with the seven high dam system. The only possibility of constructing a future power development would be by the use of water power generated at the existing high dams. The building of a power house, intakes, etc., in that area would be a very difficult and costly procedure and would probably not be feasible. It would necessitate the blowing out of portions of the existing dams. If the possibility of the future production of power is not preserved in the structure as originally built, it would hardly be practicable in the future.

The estimated cost of the Wheeler project, including the power house and the emplacements and the installation of one generating unit, is $22,548,000. Without the power house, the emplacements and the generating unit, it would cost approximately $5,000,000 less, or $24,564,000. A dam

similar to Pickwick without the power house and emplacements would cost $19,000,000. As Pickwick is planned, without generating units, it will cost $22,000,000. The Army was planning to install three generators at Norris.

If I were instructed to improve navigation on the Tennessee River, reduce flood waters in the Tennessee River basin, and reduce flood waters in the Mississippi Valley by works on the Tennessee River, I cannot think of any structure or combination of structures which would accomplish these multiple purposes as well or as economically as high dams in the main stream of the Tennessee River, such as Wheeler and Pickwick, operating in conjunction with storage dams on the tributaries, such as Norris. I doubt whether any system of structures could be designed which could accomplish these purposes as effectively. I think the general set-up would be essential to the accomplishment of these purposes.

Upon **Cross-Examination** the Witness Testified as Follows:

I know of no license issued since 1930 by the Power Commission for projects on the Tennessee River. I did not mean to state that no private interests had consulted the Federal Power Commission with reference to such projects. I know of no project by private individuals which would compare with the reasonably complete development of the Tennessee River.

There are no present plans as to the installation of emplacements at all projected high dams, but I believe that is the ultimate intention. Nothing has been authorized except the projects under construction and no further plans have been made, but investigations of various sections of the valley have been going on as fast as we could prosecute them. Projects are under way for making bor-

ings in determining different reservoir capacities and possible heights, but this is entirely with a view to finding out whether they are feasible or not or whether they might ultimately fit into the general picture and not as preliminary to the approving of plans for construction. I know of no projects that have been authorized in addition to the ones under construction. It is, however, the ultimate intention to complete the navigability of the Tennessee River from its mouth to Knoxville. We are investigating the possibilities and it appears that most of the dams will be high dams for the combined purpose of navigation and flood control.

A number of the sites mentioned in the 328 Report have not been investigated at all. We are considering Aurora, Pickwick which is now under construction, one in the vicinity of Guntersville, one at the so-called Chickamauga site just above Chattanooga, the White Creek site, and the Coulter Shoals site.

I have somewhere a purely hypothetical figure as to the potential hydro-electric capacities in that series of dams. Most of them were taken out of House Document 328 except for the dams now under construction. Except as to the ones which we have recalculated, I have no substantial criticisms of the estimates indicated in the 328 Report. We have established our own figures for Pickwick and Wheeler and generally for Aurora, and we have made rough calculations on the others. At Wheeler, we are providing intakes for eight units. Six of these might be sufficient and they would probably have a capacity of 32,000 KW each. We are providing eight stalls because we haven't had time to investigate the full possibility. At Pickwick we are providing six stalls. The ultimate capacity is limited by the velocity of the water and would be somewhere around 34,000 KW each, that is, 204,000 KW.

At Aurora we have made no studies as to the exact capacity for which it might be advisable to make provision. The capacity which is given in House Document No. 328 is greatly in excess of anything that we would consider. The figures on capacity in House Document No. 328 are very high in each instance because they adopted a figure to set up as a comparative basis between all projects. The capacity at Aurora is given as 402,000 KW. I think that is nearly double what we might consider on the basis of the knowledge which we have gained at Pickwick. If we installed all six at Pickwick and used 34,000 KW units, that would be 204,000 KW. The drainage area between Pickwick and Aurora is not very much greater so perhaps we would get around 240,000 as against 420,000 given in House Document No. 328.

Upstream from Wheeler, we have not carried our investigations to the point where we have made any determination of capacity. We have investigated the possible locations for a dam at the Guntersville site.

I do not know what project is represented by the item of $6,000,000 in the budget for a main river dam. The Board was requested to make up a budget anticipating expenses for the coming year. When I was asked what dam we wanted to build next, I said I did not know; that we had not investigated that far, so I think they put in the average figure which would be required for drainage, sites, excavations and access roads and that sort of thing, per dam on the main river. The same thing is true on the tributaries—the Board reserving until after adequate study the determination of which one shall be constructed first. The estimates of installed capacity given in House Document 328 are too high. As a rough guess, I would say it would be one-half of the figures there shown for the other dams. Above Chattanooga we have made no investigation whatever.

When we have time to develop the investigations of those studies, we will make provision for dams above Chattanooga. The investigation of a system of that sort is a question of years to get the answer as nearly correct as possible. We are making those studies as fast as possible. The completion of the project on the Tennessee River would be the ultimate purpose. I am simply charged with the investigation of sites and have no authority to say that this or that site will be used. I am charged with the duty of investigating all sites which appear feasible to complete the navigability of the river and also the completion of tributary dams in the upper regions of the Tennessee. No one knows where they shall go or what reservoir volumes are obtainable.

I have heard no statement in discussions with anyone on the staff to the effect that they have taken steps for the purpose of preventing the construction of dams upon the tributaries by anyone else. I heard Dr. Morgan's statement to the effect that they had purchased some tracts in various reservoir sites.

I stated that if a private licensee were to construct a dam in the vicinity of Pickwick, it would probably be built at Parkers Landing because naturally the power company would be interested in building where they could get cheaper power. They could not build without the consent of the Federal Power Commission, but as I understand it the Power Commission has no authority to instruct the company to build a dam at Pickwick Landing. The construction of a dam at Parkers Landing would require a less expenditure of funds. There would also be less head, but power could be produced at Parkers Landing for about two-tenths of a mill less than at Pickwick. At Pickwick Landing site, we get six feet additional. This gives an additional head at a slight additional expense and will be

less likely to be drowned out by floods below. I haven't the exact figures as to the difference in cost between the two dams, but I believe it would be in the neighborhood of four or five million dollars. We drew up preliminary plans for both sites and on the basis of these comparative preliminary layouts, we made an estimate of quantities and tried to apply comparative unit cost to those. Including the low dam and the saving in maintenance and operation in the low dam, the cost of the two would be on about the same basis.

I know that the Alabama Power Company made an offer to lease the energy of Wilson Dam and I was familiar with the offer at one time, but I cannot now remember it. This offer was declined, I believe, because the ultimate disposition of the Muscle Shoals energy had not been determined. The power companies in that area enlarged their capacity in 1928.

I filed an affidavit under date of November 7, 1934, containing the following statement: "I am informed and believe, and upon such information and belief, aver that unless potential water power which is necessarily created through these dams and their adjoining reservoirs," etc., "the public will be deprived of an opportunity to use this potential electric power to its advantage."

The combination of units which has been selected for the first construction by the Tennessee Valley Authority, is, in my opinion, the most beneficial to navigation. The existing Wilson lake is not now navigable for the type of traffic which it can accommodate because it has no sufficient outlet. It is navigable for stern-wheelers, a few small barges and that sort of thing. The completion of the projects under construction will give this lake a navigable outlet to the waterways of the United States with a six and one-half foot navigable depth. The Army engineers

spent approximately $70,000,000 to get a six foot channel from St. Louis to Kansas City, and they consider that a very valuable project. We will have the same thing out of the lakes which we are constructing and these lakes will improve navigation over sections which are extremely bad and are really of no use until improved.

I did not recommend the construction of Wheeler dam as it had been decided upon before I came with the Tennessee Valley Authority on October 18, 1933.

Upon direct examination I was asked if I would have picked out the existing projects if I had been considering power projects and I said I would have selected Wheeler but wasn't so sure about Pickwick. I might have selected Pickwick had I been interested in the ownership of Wilson and wanted to benefit that existing property from the power standpoint. My investigations have been primarily from the viewpoint of navigation and flood control and I have not studied the situation in the rest of the valley sufficiently to know whether this combination is the best for power. The result of the existing projects will increase prime marketable power from 55,000 KW to approximately 202,000 KW without taking the steam plant into consideration. This includes the Wheeler unit and releases and the Norris unit and releases. The unit at Wheeler is to be completely installed with the turbine. I don't know how far toward completion a second unit at Wheeler will be carried under the existing plans.

I am not familiar with the plans of the Corps of Engineers for producing power to operate the lock at Wheeler.

I testified upon direct examination that if conflicts were allowed to arise between power and flood control and navigation, the drag would be on power the way we were planning on operating. I later said that under the best sort of

operation I didn't see much reason for allowing the conflicts to occur.

The hardship on power production due to operation for the primary purposes of navigation and flood control might be much greater with a series of private developments than with unified ownership. There would not be the same incentive to use the power for the purpose of distribution in the case of the Tennessee Valley Authority as there would be with private ownership, because so far as I know Tennessee Valley Authority places power after navigation and flood control, whereas the sole purpose of private utilities is power generation. I am familiar with the power program of the Tennessee Valley Authority only from what I have read in the newspapers, etc.

My general province consists of general hydraulics, navigation possibilities, flood control and power possibilities. I am charged with the duty of complete investigation for different purposes and I investigate the entire matter. I have conducted no investigation looking to the marketing of the power. I simply investigate the possibility of a certain project.

I know in general what has been done with relation to acquisition of transmission and distribution systems and entry into contracts for the marketing of power. I know nothing of the future plans. I know there was an attempt to serve Knoxville and that we are now serving Tupelo. I have not been called upon to estimate the increase in power capacities with a view to marketing of power. I have been called upon simply to estimate the number of units necessary in a plant to produce a given amount of energy. I make no prediction as to when it might be done or by whom or anything of that nature.

I conferred with Messrs. Jackson and Moreland as

to the system characteristics on which they were to report and I, personally, supplied some of the data needed by them. I did not give them the projected demand for the year 1940. That was supplied by others to me and I was simply asked the question whether I could supply the necessary facilities. Someone in the power division compiled these figures. There were a number of persons involved, but I do not recall who they were. At the conference at which these negotiations took place, Mr. Evans, Chief Electrical Engineer, was present and also Messrs. Hapgood, Almon and George, and I think one or two others from the power division. I don't recall whether Mr. Woodruff was there at the time of the negotiations. He came in about two hours after the conference started.

In giving Jackson and Moreland data for their study for the year 1940, Tennessee Valley Authority estimated a total of 288,000 KW of firm capacity. I was not asked whether the production units of the Tennessee Valley Authority would supply that firm load in 1940. I was asked how many additional units would have to be put in at Wheeler and Wilson in order to supply that load. I do not remember exactly, but I think my recommendations were that the capacity at Wheeler would have to be increased either to four or six units. We were figuring on installing in steps of two and I believe it required about five additional units at Wilson. The capacity would be the same as on the units now installed. At that time Pickwick had not been begun.

I am familiar with the report of K. G. Hapgood of the electrical division, dated January 4, 1934, which refers to the conference as having been held at the Tennessee Valley Authority office on July 19 and 20, 1934. I am not

familiar with the suggestion of the Tennessee Valley Authority to Jackson and Moreland that three additional generators would be installed at Wheeler dam by 1940. I am not familiar with the Jackson and Moreland report. My recollection is that the Commonwealth and Southern said they wanted an eight hour, five day basis, and later changed their minds and said they wanted substantial firm power on a steam replacement basis. I think that is where the three units come in. In order to supply what they wanted, it would take three additional units at Wheeler. Anyway, that answer was given merely in reply to questions on secondary power set up by Mr. Sholtz. It was only the prime capacity on which the projected figure for 1940 was based. I think that was the total of the units. I don't know. I have never seen this report before. I don't know anything about it.

In selecting our low flow figures, we first used the year 1925. For the purpose of studies in regard to steam replacements, Mr. Sholtz said that 1931 was really lower, so we used that as the year which would require maximum steam replacements. For some purposes, we used 1925 and for others, 1931. For allocating the value of Wilson, we were really using a compromise between the two. It makes a difference whether we are considering the river above or below Wilson, which year we use for the minimum flow. It was either 1931 or 1925 or a correction somewhere between the two to allow for a small amount of storage existing and built on the river since 1925. In the data given to Jackson and Moreland, we have considered only power entirely generated on the Tennessee Valley Authority system. The effect of the interchange contracts may have been worked into the hydro picture later. I don't know. We gave them our figures which represented solely

hydro production on the Tennessee Valley Authority plan. The pooling of the power required by the Tennessee Valley Authority was another item given to Jackson and Moreland for their information. I assume that the information secured by Jackson and Moreland was used to determine electrical machinery and transmission line characteristics in connection with the interconnection with surrounding systems. This is in accordance with the memorandum that was written in connection with the conference.

1034 is the top of the crest gates at Norris dam which is the top maximum elevation before water passes over the dam. The water could be drawn down to a minimum level which would be 72 feet below 1034, or elevation 962. This, in general, is the range in which we expect to operate the conveyor system, although I doubt whether the range would go up to 1034 because that would imply as big a flood as we have on record, and barges would scarcely be out on the lake during a storm which would contribute any such flood. The sketch of the coal conveyor is a fairly accurate representation, although it was prepared by the artist and not from sketches which we made ourselves. It illustrates the principle although there are some things in the picture which might not be correct engineering.

Upon **Redirect Examination** the Witness Testified as follows:

At the conference regarding the Jackson-Moreland report to which Mr. Johnston had made reference, Commonwealth and Southern, Electric Bond and Share, South Carolina Power and Light Company, and the American Gas and Electric Company, all participated. The conference was to determine what these different represen-

tatives would bring together by way of information, and the figures submitted were to a large degree hypothetical. I don't remember that any actual plans were submitted at that time. I know of no action taken by the Board of Directors on the Jackson-Moreland report. I have never seen the report myself.

Before the Authority undertakes construction or commits itself to any plan for a definite project it thoroughly investigates the feasibility of any such project. My instructions are to investigate all possibilities from every standpoint before it is authorized. I presume that future development of any plan must depend upon the action of Congress from time to time.

Upon **Re-Cross Examination** the witness Testified as Follows:

I have obtained no statement from my superiors as to their plan of financing these projects. I know nothing except what I have learned from reading the Act and from hearing Dr. Morgan's testimony. The budget shows that all of the receipts from the commercial operation of the Tennessee Valley Authority properties are to be put into the extension of additional systems. I heard Dr. Morgan testify to that. It depends upon Congress whether we get the money to buy distributing systems as stated in the budget. I really know nothing about the use of money derived from operations.

When I spoke of improving the property at Muscle Shoals, I referred particularly to increasing the power capacity and thereby making Wilson Dam that much more valuable to the Muscle Shoals property. The increase in value arises from the increase in power capacity. I express the increase in capacity in terms of continuous power. On

a 50% load factor, including the interconnection, we would have 404,000 KW. The 90,000 KW refers to Wilson alone. On a 50% load factor that would be 180,000 KW and the installed capacity is 184,000 KW, so Wilson Dam could carry this load. We could peak it only if Pickwick were built so as to eliminate the navigation restrictions, but on this assumption it would carry the existing units to capacity on the 50% load factor. The average load factor of the Alabama Power Company is around 62% for the system as a whole. A 50% factor applied to the 202,000 KW would be 404,000 KW, but the installed capacity contemplated at the present time would not carry that load. That would be at least 300,000 KW on a 50% load factor with only one turbine installed at Wheeler Dam, although that would depend somewhat upon the shape of the peaks. A sharp peak which didn't require much water could be carried at Norris throughout the year. If the peak was a five-hour peak and very high, it would be too much to carry at Norris because we are saving that for low water operations. In other words, the capacity which would exist on the system depends on how much water would be necessary to carry that peak. It would be necessary to set up a load curve before we could tell.

The figures to which reference has been made, took into consideration only the water power and not the steam plant. I do not know the number of kilowatt hours which the steam plant would have to turn out in order to produce 90,000 KW continuous capacity with Wilson Dam in its present condition. It would be necessary to operate it in the low water season, approximately five months. That would depend upon the peak we were trying to carry. That, again, depends on the load curve. If that is on a continuous basis, it is obvious that the steam plant would have to be turning out 40,000 KW at the time Wilson was

releasing 50,000 KW. I have not the data available as to the period of operation of the steam plant necessary in an average year and in a low flow year. So far as power is concerned, approximately the same result would be obtained by using the existing steam plant as a standby as by the construction of Norris Dam. This question has been considered by the Tennessee Valley Authority staff. It has been all figured out and set up in the office. I have investigated the question thoroughly before.

I know of the application of the East Tennessee Development Company for permits for the construction of a number of dams. It was not a license, but simply an application. I don't know what final action has been taken. I read, perhaps six or eight months ago, that the Corps of Engineers reported that the project seemed to be feasible, but recommended more investigation. I do not recall the exact number of dams. I don't remember that that was an application for eleven dams at that time, as you suggest, but I think they specified that they intended ultimately to carry out some such program. I don't know whether this antedated the Rivers and Harbors Act of 1930 or not.

The minimum depth with a five foot drawdown on the Wheeler pool would be nine feet at the upper end of the pool. By a five foot drawdown, I mean five feet on the main pool levels. That might be a little less at the next dam above depending on the stage of the water, but the drawdown at the next dam upstream would not have to be more than five feet, with the five foot drawdown on Wheeler pool in low water conditions.

The 300,000 acre feet which I stated would add 1,000 CFS to flow of the river below Pickwick, would be released through the turbines or spillway gates, depending upon which was operating at that particular time. At the

bottom of the gates, the water would be discharging through an orifice with a head of ten to twelve feet, depending on the amount of drawdown. Over the spillway, it would have a head of approximately five feet. That is something customarily experienced where flood waters are being discharged through the spillway, and it has all been provided for in the design. The theoretical head at the foot of the spillway under this condition would be about fifty-six feet per second that would be reduced to around fifty feet per second at the toe of the spillway.

I do not recall the design of the Corps of Engineers for the installation of a generator for the operation of the lock at Wheeler Dam. I simply looked at the general plans. I have very little to do with designs. That is the function of the engineering department. All I really looked at in any detail were some of the earlier general plans for Wheeler lock. I assume that whatever the Corps of Engineers put in would be satisfactory. I haven't the figure and could not say without knowing what it is. The 750 KW installation at Wilson Dam seems to work satisfactorily.

I could not say whether Chickamauga is the most feasible unit in our program at the present time, because we have done very little investigation of this site. A dam in the vicinity of Guntersville would be of the most benefit to navigation as it would produce a reasonable navigable depth into Chattanooga. If a dam is built at Chickamauga, it would be a navigation and flood control project with intakes undoubtedly provided so that power facilities could be installed as required. The site which the Army engineers recommended for Chickamauga in House Document No. 328 is just above the mouth of Chickamauga Creek. However, the Corps of Engineers has reported that the foundations are extremely bad at that point, so apparently

the whole area would have to be thrown open for investigation before we could decide where to put that dam on account of the uncertainties as to the foundations. To use the dam for navigation or flood control, it would have to be outside the city limits of Chattanooga. The city property there could not be flooded regardless of the type of the dam. It would probably be prohibitive in cost. We have made no studies whatever as to the site, but we shall probably undertake studies in the near future as we get to it.

It was largely upon my recommendation that Tennessee Valley Authority decided to go ahead with Pickwick at that site. I also recommended as to the number of intakes which should be provided to avoid waste of power if it should ever be developed at that point on the Tennessee River. I indicated not the maximum amount that could be installed, but what I considered the maximum amount that would be economical for anyone undertaking a power development at that site. I didn't think it would be right to foreclose the possibility of future development of power. On the basis of information available, it looked as though four emplacements might be sufficient there. To play safe, we had two more installed to take care of eventualities. It is a question of what the load factor might be on the system and all sorts of things which cannot be presently predicted. The decision as to the number of units at Wheeler also resulted from studies of which I had charge. I recommended eight stalls. The purpose of my recommendation was to make provision for the maximum economical capacity for turbines by whomsoever developed. I was consulted to some extent as to the actual installation of the generating unit. The one installed will approximately absorb the prime capacity of the river from the upstream developments in process, but that was not the

basis of the recommendation for the installation of that unit. The reason for that recommendation was that if we put in the intakes on a stratified limestone and if the draft tubes were to be excavated below these it would be a very hazardous operation to excavate for the draft tubes downstream for the intakes later on since if the stratified limestone were disturbed the intakes might slide out Therefore, it was obvious that we had to line that rock excavation for the draft tubes and put in the lower part in order to hold them from sliding so that water going through these intakes during construction would not erode the rock excavations below. In view of this, it was necessary to determine very closely the type of draft tube which would be used and we could not determine that without actually buying the unit and getting designs from the manufacturer of the type sought in order to provide sufficient excavation for it. On that basis, we considered ourselves justified in putting in one unit which would give us the design of the draft tube and the scroll case so that whoever developed the rest of it would have sufficient excavation to go ahead. We do not know whether we can load up that unit or not. That has not been considered by me at all. We are just installing the lower part of the draft tubes, that is, lining the excavations for the other seven. We are not putting in complete draft tubes. If we didn't get the excavation right in the first place, it would present serious difficulties when an attempt was made to install the others. Only one unit is being completed and on the other seven emplacements we are doing only such work as is necessary to preserve the integrity of the excavation. The only reason that we put in one unit was to determine the design of the other draft tubes. I think if it had not been for that, no unit would have been installed at Wheeler at the present time. Those of us who made that recommendation had to

put up a scrap to get the money to spend on it. We are leaving to another department the question of disposing of the power.

Upon **Re-direct Examination** the Witness Testified as Follows:

In my statement upon direct examination as to the status of the proposed private projects on the Tennessee River, I did not mean to state that no preliminary studies had been made. I was talking about actual licenses and actual plants. When I talked about the seven high dam program, I was discussing it on the basis of House Document No. 328. This is especially true with reference to the river above Chattanooga. We have never made an independent study of the upper river.

The figure of 202,000 KW which I gave represents the entire interconnected system of Wilson, Wheeler and Norris.

From the inception of the plans of Pickwick, the Army was considering designing a lock and was finally asked to design it. They fixed its general location and then initiated experiments at the U. S. engineering laboratory at the University of Iowa to determine the location for spillway gates, the arrangement of service gates and emergency gates, the angle at which the discharge from the power house might enter the river below, all as having a bearing on the creation of unfavorable currents below the locks which would interfere with the entrance of the barges and to determine measures which could be taken to eliminate to the greatest extent possible, any unfavorable currents. They are still working on that and our designs are being made to conform to their desires in the matter. In fact, they determined the angle of the dam with the lock and everything of that nature.

They have a complete scale model of the whole Pickwick project for some distance upstream and downstream from the dam, passing water through that on a scale with the unfinished structure, studying the whole lay-out in every detail and we are following their recommendations. That work is all being done by the Corps of Engineers.

There has been considerable shifting in the plans regarding a lock at Pickwick. First of all, the lock was placed on the south side of the river because the navigable channel was on that side and the power house was placed on the north side because they couldn't both be together. That made the intakes for the power house much less accessible for power purposes but it set the lock right. Since then, we have changed the angle of the lock with the dam and the angle of the dam with the lock several times to meet the desires of the Corps of Engineers.

Upon **Re-Cross Examination** the Witness Testified as Follows:

I know nothing of the negotiations by the Authority for transmission and distribution systems for which money was requested in the current budget. My work stops with the investigation of the various sites and I have nothing to do with any commercial end of the Tennessee Valley Authority activities, transmission lines or anything of that sort. I have heard no discussion in the staff as to plans for acquiring any system and the first I heard of it was when you were questioning Dr. Morgan. I think I heard Dr. Morgan say that work on the interconnection between Wilson, Wheeler and Norris had been started again. That is all I know about it.

With reference to the question of licenses, preliminary studies by the private agencies are necessary before they can formulate plans for the construction of dams.

Upon **Re-Direct Examination** the Witness testified as Follows:

At Norris the concrete is approximately one-third placed. The coffer dams have been removed and the river is turned through the permanent diversion channels. At Pickwick nothing has been done beyond preliminary exploration and the building of access highways, some work on the camp and a little minor excavation. At Wheeler the job is approximately 40% completed. A good deal of concrete has been poured in the intake and power house area and about one-half the spillway is pretty well along as far as concrete work goes.

(Counsel then read into the record from House Document 395, 73rd Congress, 2nd Session, a document entitled "Message from the President of the United States Transmitting a Preliminary Report For a Comprehensive Plan for the Improvement and Development of the Rivers of the United States," etc. The report is dated June 4, 1934. On page 53, the section on the functions of the Federal Power Commission was read. This section was briefly as follows: The Federal Water Power Act of 1920 defines the function of the Federal Power Commission in its relation to the development of power resources on the navigable waters and also gives a definite jurisdiction with reference to the interstate transmission of electrical energy developed on navigable waters or public lands of the United States in states which have not provided proper agencies for effectuating such regulation. The Commission is authorized to de-

termine the legitimate investment of licenses in projects as a basis for ultimate recapture, and also for rate regulation and for the expropriation to the government of excessive profits until the respective states shall make provision for preventing excessive profits or for the expropriation thereof to themselves. This Act further authorizes the Commission to investigate water power resources of the nation and to determine which sites and government dams may be advantageously developed by the United States for public purposes in addition to navigation.

Water power constitutes the principal and sometimes the only source from which the federal government may reasonably expect a revenue to liquidate its investment in the development of waters which come within its jurisdiction. No tolls are charged upon the inland waterways and the benefits from flood control and the prevention of soil erosion are always indirect. Water power development alone can reasonably be expected not only to pay its own way but to yield substantial revenue to the federal government. Such expectations can be realized, however, only if water power projects chosen for public development are selected with proper regard to their soundness from an engineering standpoint and their economic feasibility.

EDWARD A. SHERMAN,

Called as a Witness on Behalf of the Defendants, Testified upon **Direct Examination** as Follows:

I am associate forester in the government service. I graduated from the Iowa State College of Agriculture in 1891 with the degree of Bachelor of Science. I am a member and a fellow of the Society of American For-

esters, and have served as president of that organization. I was closely connected with the land classification that has been carried on by the Forestry Service. I assisted in the preparation of the document which is entitled "Relation of Forests to the Control of Floods in the Mississippi Valley," Document No. 573, 70th Congress, 2nd Session. This survey was undertaken in consequence of the Mississippi flood of 1927. It was evident that Congress would want to know what could be accomplished by reforestation as well as what could be done by the construction of engineering works. The Forestry Service decided that a study, including the whole drainage area of the Mississippi River, should be undertaken. I was placed in charge of that study. We studied the Tennessee specifically as six units, the Clinch River, the French Broad, the Holston, the Hiawassee, the main stream of the Tennessee and the Little Tennessee. By the Flood Control Act of May 15, 1928, Congress directed the President to ascertain from the Secretary of Agriculture what influence forest cover would have upon floods. In this study we found that the major problem was not on forest land but upon non-forest land. The outstanding feature of each report was the damage upon cultivated land. We found, and so reported, that the condition of the forests had undoubtedly assisted in some degree in reducing the crest of the flood. We called attention to the fact that there was a serious agricultural problem beyond the scope of forestry. In order to procure cover upon agricultural land some method other than reforestation must be adopted, unless the land is to be turned back into wilderness. I am acquainted with the professional standing and reputation of Leonidas Chalmers Glenn and am acquainted with his work entitled "Profes-

sional Paper No. 72, Denudation and Erosion in the Southern Appalachian Region and Monongahela Basin." That report is outstanding and generally recognized as authoritative.

At this point there was offered in evidence as Defense Exhibit No. 38, certain marked excerpts from this report, which were in substance as follows:

Excerpt from page 5. The report presents a brief summary of the results of an examination of the Southern Appalachian Region during 1904 and 1905. A detailed examination was made of an area some 400 miles long from a point near Pulaski, Virginia, southward to Gadsden, Alabama, and from 75 to 125 miles wide, extending from the valley of East Tennessee, in which the Tennessee and Holston Rivers flow, across the mountains to the Piedmont plateau. The Tennessee River was followed to its mouth, a distance of over 700 miles.

Excerpts from page 14. From the slopes along these streams an increasing amount of waste is working its way down their channels, filling the dams and destroying their storage capacity. Storage basins constructed in this region in recent years are rapidly filled with silt, through which the stream maintains a channel only large enough to carry the ordinary flow. In many dams the silt has been so great as to practically destroy the storage capacity originally provided. All power plants recently built practically ignore storage and depend on the flow of the stream only. Another result of erosion is the greater frequency, greater suddenness and greater height of floods. During a single year the flood loss in these Southern mountains reached some $18,000,000.00. Still another result is a change in the normal stream flow. The period of high water is shortened and made abnor-

mally high, while the period of low water is correspondingly lengthened and made abnormally low.

Excerpt from page 15. In forested areas surface erosion is at a minimum. The forest soil is effectively protected from the blows of the rain drops that cause the loose soil on the bare surface of a freshly plowed field to melt away. The flow of water is checked by the leaves and litter and is absorbed by the moss and turf.

Excerpt from page 16. Streams that flow from the forest land with graded slopes show certain well-defined characteristics. During rains they rise more slowly than similar streams in cleared areas. Streams of this class carry almost no load of silt or waste. Such stream channels change slowly.

Excerpt from page 18. Though forest tracts in the Southern Appalachians are under natural conditions subjected to relatively little erosion, man's activities in clearing the forests are causing destructive erosion.

Excerpt from page 25. Wherever mountain stream basins have been extensively cleared the normal flow of the stream has been changed. This change is largely due to increased erosion. Erosion once begun, soon develops gullies that furnish so much sand, clay and cobble to streams that they become overloaded and are unable to carry away all the waste that is brought to them. The excess waste is deposited first in the channel until that is practically filled, and then over the alluvial flood plain, which is then converted into a barren waste. The waste then works down stream, filling dams and pools as it goes. It soon gets into the navigable parts of a great river system, such as the Tennessee, making more difficult the problem of maintaining navigable channels.

Excerpt from page 29. There is abundant evidence on rivers, such as the Tennessee, of increased silting in the navigable portions of streams because of the increased erosion resulting from deforestation.

Excerpt from page 81. It seems beyond question that deposits in the channel of the river are greater today than fifty years ago. There is evidence, wherever it has occurred, that it has either been recent, or, if long continued, has been more rapid of recent than of former years. Such changes can be attributed to the changes that are occurring in the mountain headwaters of the river, in consequence of which much greater amounts of sediment are now being furnished to it than ever before. The silt is over-loading and choking the middle and lower part of the river, and year by year is undoubtedly making the maintenance of navigable channels more difficult.

The reports of the United States Army Engineers show very clearly the changing character of the bed of the Tennessee River, due to silting and sedimentation. The early reports pay very little attention to the necessity for gravel excavation or dredging, and emphasize the fact that the river was admirably suited for open channel improvement. The later reports give evidence of an increasing necessity for dredging and emphasize the failure and impossibility of open channel work. The conclusion is that the task of improving a river like the Tennessee under the conditions of erosion and silting that exist in its basin is never ending, and that dredging will always be necessary to maintain an open channel as long as the present conditions on its head water tributaries prevail. A single sand bar may effectually block the river and render useless the locks and dams, nullifying the results of the expenditure of millions of dollars.

The testimony of the Witness Continues:

In my opinion, the conclusion arrived at in that report are sound. As the result of my studies, I have reached the conclusion that soil erosion is the most serious national problem confronting the country. We have a total of 1,934,642,279 acres of land in the United States. Erosion is a serious problem upon 1,135,000,000 of those acres. It is decidedly more serious on cultivated lands than on others. The lowest estimate is that an equivalent of 400,000 acres of top soil is being carried down the Mississippi every year. Approximately 35,000,000 acres of land have been practically totally destroyed.

At this point there was offered in evidence as Defense Exhibit No. 39 the table on page 171, Part 2 of the Report of the National Resources Board; such table having been referred to by the witness as showing the acres subject to erosion. It being impracticable in the opinion of the Court to reduce the substance of this table to narrative form, the same is here set out in words and figures as follows:

Table 18.—Summary Table of Erosion Conditions in the United States.

(A generalized table of 28 erosion classes combined into 8 classes used in the accompanying generalized erosion map of the United States.)

Symbol	Description of generalized erosion class	Acres
1	Erosion unimportant except for small local areas (much good farm, forest, and grazing land)	798,870,186
2	Moderate sheet erosion. Considerable gullying locally. Much of the land has lost from ¼ to ¾ of the topsoil with noticeable to serious reduction in yields over large areas. In western grazing areas much erosion locally due to hard usage.	612,909,676
3	Severe sheet erosion with moderate to severe gullying. Much of the land has lost all the topsoil. Much severe erosion in western areas due to overgrazing. Some fair to good farm land locally	194,825,391
4	Moderate wind and sheet erosion, considerable gullying locally (mixed grazing and dryland farming; generally fair grazing, but mostly poor for farming)	101,235,607
5	Severe wind erosion with moderate to severe gullying (mostly submarginal for cultivation; fair to poor grazing)	82,353,542
6	Essentially destroyed by wind erosion (generally only use is for establishment of grazing)	8,738,565
7	Essentially destroyed by gullying (mainly suitable only for forestry)	13,143,865
8	Intermixed mesas, valleys, scablands, bare mountain tops, and canyons (generally only fair grazing) much depleted by overgrazing. Some good valley lands and mesas. Erosion generally exceedingly serious and becoming worse	122,565,447

Forest cover has a very material effect in reducing floods and protecting soil from erosion. This is brought about by interception, absorption, evaporation, and retardation. Any proper sort of vegetative cover will produce a similar result. Any cover that prevents the direct impact of the rain with the soil is helpful. Forestry is not the complete answer to the erosion problem. We can not return the entire nation to a wilderness. The only substitute is thick growing vegetative cover upon cultivated lands. The influence of forestry upon stream flow and erosion has been set forth most completely in a report by Dr. Raphael Zon, Director, Lake States Forest Experiment Station, entitled, "Forests and Water in the Light of Scientific Investigation." I should like particularly to call attention to the bibliography contained in this publication.

(At this point counsel directed the attention of the Court to the report just referred to by the witness and also called the attention of the Court to the Act of March 1, 1911, 36 Stat. 961, as Amended, by the Act of March 4, 1913, 37 Stat. 828, which are Sections 500, 513, 516, 517, 518, 519, 521, 552, and 563 of Title 16, U. S. C.)

(At this point there was offered in evidence as Defense Exhibit No. 40 certified excerpts from a report entitled, "Silting of Reservoirs in the Chattanooga District," being Appendix II of "Report on Flood control of Tennessee River and Its Tributaries," submitted to the Chief of Engineers, United States Army, under date of August 20, 1932; which excerpts were, in substance, as follows:

> The Parksville Reservoir is located on the Ocoee River, having a drainage area of 600 square miles above the dam. (Page 10.) Silt surveys were made

by the Tennessee Electric Company in 1917-1921 and 1929 and a survey was made by the U. S. Engineers in 1930. (Page 11.) These surveys show a total accumulated fill of 21,839,000 cubic yards. (Page 22). The original gross capacity of the reservoir was 97,000 acre feet. During the period from 1912 to 1930 there was deposited a total of 20,672 acre feet of silt and sand, causing a reduction in gross capacity of the reservoir of 21.3%. (Page 22.)

The Cheoah Reservoir is located on the Little Tennessee River with a drainage area above the dam of 1,620 square miles. (Page 28). Silt surveys were made in 1922 and 1930 (Page 29.) The original gross capacity of the reservoir was 41,625 acre feet. (Page 29.) From the date of completion of construction, 1918 to 1930 survey, 4,350 acre feet of silt (7,017,986 cubic yards) was deposited, (Page 29) causing a corresponding reduction in gross capacity of 10.5%. (Page 34.)

The Hales Bar Pool is located on the Tennessee River just below Chattanooga. The drainage area is 21,400 square miles. (Page 39.) A silt survey was made in 1930 (Page 44); from the date of completion of the dam, November 1913, to the 1930 survey, 16.92 years, there was deposited in the Pool a total of 45,514 acre feet (73,428,725 cubic yards) of silt, (Page 45) causing a reduction in capacity of 29.1%. (Page 45.)

DR. ADRIAN PIETERS,

Called as a Witness on Behalf of the Defendants, Testified as Follows:

I am Head Agronomist of the Division of Forage Crops and Diseases of the United States Department of Agri-

culture. I graduated in 1895 from the University of Michigan with the degree of Bachelor of Science. I later attended Cornell University and Heidelberg University in Germany, taking the degree of Doctor of Philosophy in 1915. I have been appointed upon two committees of the National Resources Board. I have here a list of my various publications which cover mainly various studies of legumes.

(At this point there was offered in evidence as Defense Exhibit No. 41 a list of publications by Dr. Pieters, which exhibit has been omitted from this narrative.)

Our Division has charge of all investigations that relate to legumes. Necessarily, these investigations lead us into the field of soil protection and preservation. The phrase "cropping system" is used to describe any system of crops that is suitable to any particular farm. The one crop system has been the ruination of a great deal of soil in the south. That is the worst possible system. An improved cropping system for preventing soil erosion and for improving and conserving soil fertility can be developed in any soil region and with respect to any existing farming system except in extremely arid regions. The correct system for the southern part of the Tennessee Valley revolves around cotton. You could plant cotton one year, then sow grain in the winter time, and that land can then be fallowed the next summer in one of two ways. It can be harvested and plowed and sown with cow peas or soy beans, or you can put lespedeza on it. The next fall you can sow winter legumes after the summer legumes are gone. Then the next summer

you could again put it in corn or cotton. A system of that sort serves to protect the ground as well as it can be done outside of pasture sod, which is the best protection. The primary object is to increase the proportion of soil improving and protecting crops such as legumes and grasses and to decrease the acreage of bare lands or land in cultivated crops. Evidence secured experimentally establishes that cover crops protect the soil from erosion. This operates in several ways. It prevents the direct impact of the water upon the soil, which starts erosion. Furthermore, if land is covered with plants, the water flowing downhill meets with thousands of obstructions and fails to attain the headway that it secures upon bare soil. Any soil that is well filled with roots allows water to pass through it more freely than if there were no roots there. The soil is more porous. The roots serve to bind the soil. These photographs serve to illustrate the point. These are views of the same field; one side has been grown for years in corn and nothing else; the other part has been for years in alfalfa. You see the difference; the soil in the field that has been grown in corn only is tight; the other soil is porous. (At this point there was offered in evidence as Defense Exhibit No. 42 the photograph referred to by the witness showing a portion of the field that had been cultivated only in corn for several years; there was also offered in evidence as Defense Exhibit No. 43 a photograph of another portion of the same field that had been cultivated in alfalfa for several years. These exhibits have been omitted from this narrative.)

These other photographs show the difference in the way soil is exposed to heavy rains under corn, under

alfalfa, and under hairy vetch. In this picture of the corn field every part of the exposed soil between the roots of the corn causes the water to run. In this other photograph showing the alfalfa field, no matter how heavy the rain upon that mass of vegetation, it can not strike the soil. The same is true with respect to this photograph of the field in hairy vetch. When it is upon a slope, the water in running down hill meets with these thousands and thousands of little stems so that it is slowed down. (At this point there was offered in evidence as Defense Exhibit No. 44 the photograph showing the corn field; as Defense Exhibit No. 46, the photograph showing the field of hairy vetch; and as Defense Exhibit No. 45, the photograph showing the field of alfalfa. Exhibit 46 has been omitted from this narrative; a reproduction of Exhibits 44 and 45 appear upon the succeeding pages.)

Moreover, legumes have a very decided effect upon soil fertility, as they are the only plants that are able to take nitrogen from the atmosphere. The three necessary elements are nitrogen, potassium and phosphorus. Of those, nitrogen can be secured through the growing of legumes. You cannot obtain phosphorus in that way. If there is not enough in the soil, you must add it. The evidence that legumes are soil improving crops is based upon experimental data. It was found that in these Southeastern states 70% increases were secured in corn yields from the plowing under of legumes and 35% increases in cotton. Under the crop reduction program now in effect, the farmer is allowed to raise a certain number of bales of cotton. He can produce that amount on approximately half the acres of land when he uses

Defense Exhibit No. 44.

Corn, Montana, shows soil exposed to erosion

Defense Exhibit No. 45.

A field of alfalfa N. Y.

the proper cropping methods. Assuming that his allotment is 10 bales; if he raises that upon poor soil, it will require 20 or 30 acres, all subject to erosion. If he follows the proper system, he could raise that same number upon 10 or 12 acres. He saves the expense and he prevents the erosion upon all the other land that he does not have in cotton, and in addition, the land that he puts in soil improving crops is improved for use in the future. He can raise his full quota on a less number of acres and use the other acres for soil protecting and improving crops. Here are two pictures of the same field; one was taken when the farmer began his program of improvement through the growing of proper crops. That field produced about five bales to the acre. This other is a picture of the same field after five years of improvement. There is no difference in fertilizer and no difference in anything except rotation of crops. This other photograph shows half of a field that did not have any soil improving crop and the other half that was cultivated in hairy vetch, and it shows the result as to the corn crop. (At this point there was offered in evidence as Defense Exhibit No. 47 the photograph representing the corn field before the growing of legumes; as Defense Exhibit No. 48, a photograph of the same field after legumes had been grown for five years; as Defense Exhibit No. 49, the photograph showing one-half of a field with no soil improving crop and the other half of the same field after cultivation in soil improving crops; and as Defense Exhibit No. 50, the graph referred to by the witness entitled "Yield of Corn After Winter Legumes and Without Winter Legumes." Exhibits 47 and 48 have been omitted from this narrative;

a reproduction of Exhibits 49 and 50 appear upon the succeeding pages.)

Phosphorus plant food is absolutely essential in order to procure the proper cover crops which will effectively control erosion; this fact is amply supported by experimental results from the experiment stations in practically every state, especially here in the Southeast. Moreover, this element of plant food is almost universally deficient in the soils in the East and South. I am familiar with the book entitled "The Maintenance of Soil Fertility" by Charles E. Thorn. It is generally regarded as an authoritative work. I agree entirely with the conclusion expressed on page 307 of that book to the effect that the most important mineral element in human food is phosphorus, and that wherever land has been under cultivation for any considerable length of time, there will be a deficiency of phosphorus, except in the rare instances in which the soil has been naturally stocked with an abnormal supply of this element. I am familiar with the book entitled "Soils" by Hilgard. That is generally recognized as authoritative. I agree entirely with the conclusion expressed on page 65 of that book to the effect that for permanent productiveness and especially for intensive farming or gardening, a cheap supply of phosphate fertilizer is of first importance in all soils and climates. I am familiar with the book entitled "Soil Fertility and Permanent Agriculture" by Hopkins. That is an authoritative work. I agree with the conclusions expressed on pages 183 and 194 of that book to the effect that phosphorus is the only element that must be purchased and returned to the most common soils of the United States. Phosphorus is the key to permanent agriculture on these lands. If the supply of phosphorus in the soil is steadily decreased in the future in accordance with the common practice of the past and present, then poverty is the only future for the people who till the common agricultural lands of the United States.

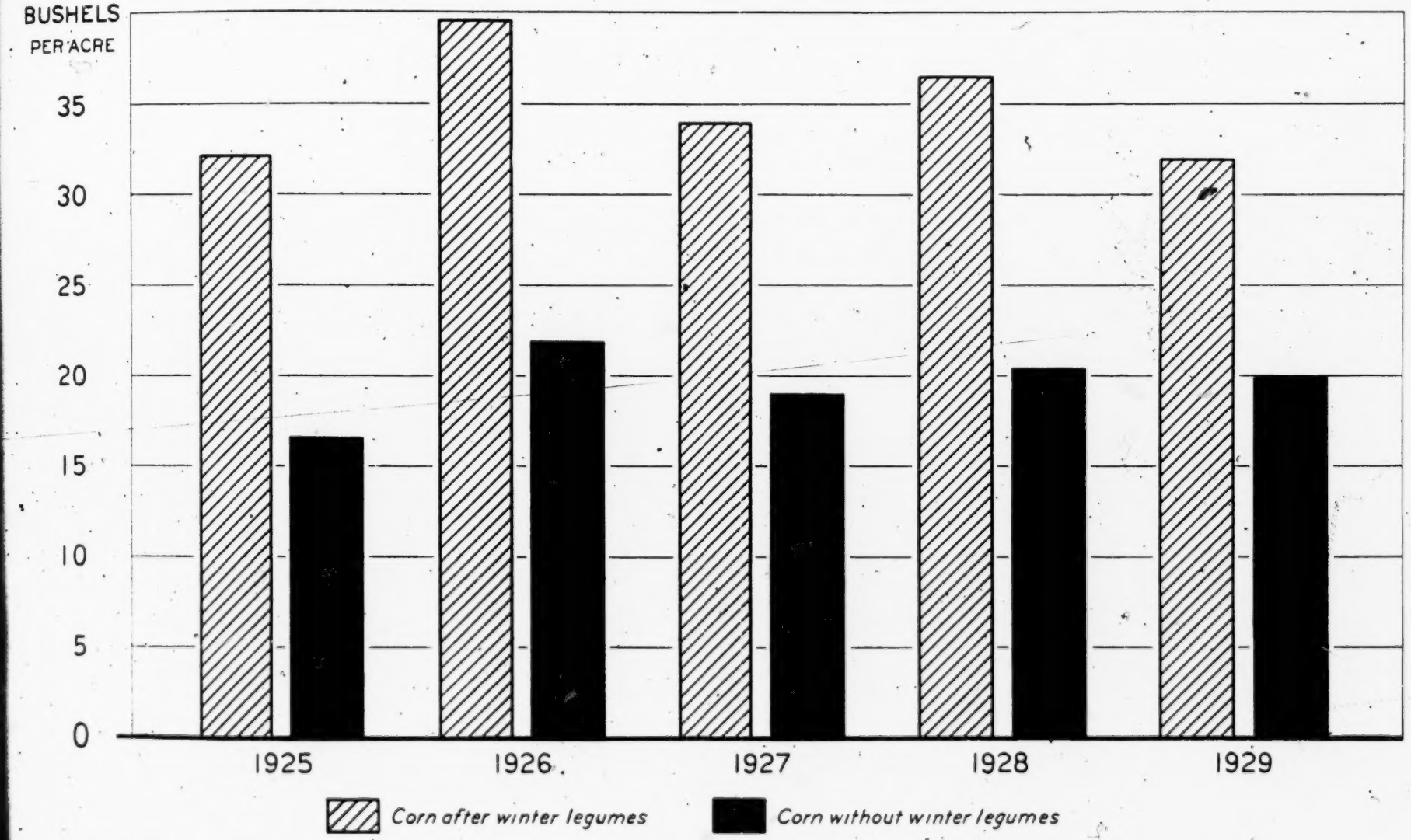
Defense Exhibit No. 49.

Corn after winter peas—right

Corn not after winter peas—left
Ozark, Alabama

Defense Exhibit No. 50.

YIELD OF CORN AFTER WINTER LEGUMES AND WITHOUT WINTER LEGUMES



U S DEPARTMENT OF AGRICULTURE

NEG 24892 BUREAU OF AGRICULTURAL ECONOMICS

EDWARD C. M. RICHARDS,

Called as Witness on Behalf of the Defendants, Testified as Follows:

I am a forester by profession, and am at present Chief Forester of the Tennessee Valley Authority. I graduated from the Sheffield Scientific School of Yale University in 1909, and from the Yale Forest School in 1911. I am generally acquainted with the soil erosion problem in the Tennessee Valley. That problem is very serious in this area; along with that is the problem of silting of navigable streams. Silting very seriously impedes the flow of the stream. Approximately 63% of the land in the Tennessee Valley is now in some form of forest cover. The greatest problem lies upon lands which have been cleared of forests. On those areas where economical farming can be practiced, the erosion problem is distinctly an agricultural one. There are, however, throughout the Valley certain areas that have been practically ruined so far as economic farming is concerned. It is in such areas that the work of the Forestry Division of the Tennessee Valley Authority is mainly concentrated. We have undertaken as our primary work the prevention of erosion on those critical submarginal lands. Our first problem was the area around the site of Norris Dam, because of the silting problem there. Our methods follow largely those that have been developed by the United States Forestry Service over the course of decades. The areas shown upon the large map in green, that is the Great Smoky Mountain National Park, the Qualla Indian Reservation, Mantahala National Forest, the Cherokee National Forest, the Pisgah National Forest, and the Unaqua National Forest are lands owned by the United States Government.

Upon **Cross-Examination** the Witness Testified as Follows:

I cannot exactly recall the geometrical ratio of silt which

is carried down and brought out by the velocity of the current, but I think it is according to the fourth power. Water running twice as fast does not erode twice as fast. It erodes many times as fast. There is a Bureau of Forestry in the Department of Agriculture. There is little or no erosion upon lands actually in forest. The erosion occurs upon lands which are being farmed or lands which are lying idle.

CHARLES E. KELLOGG,

Called as Witness on Behalf of Defendants, Testified Upon **Direct Examination** as Follows:

I am a soil scientist by profession and am at present Acting Chief in charge of the Soil Survey Division of the United States Department of Agriculture. For about 11 summers I have been engaged in soil survey work. For two years I was research engineer for the Michigan State Highway Department, and at the same time Fellow in Soil in the Michigan State College, teaching for approximately three years at the University of Michigan and for four years Professor of Soils in North Dakota Agricultural College. In a soil survey the man conducting the survey in company with an experienced soil scientist goes through the area to determine the soil types, topography, drainage conditions, physical condition, and adaptation to various kinds of plants. Our duties include not only erosion, but general fertility and the drainage problem. In the Southern part of the United States, the problem of erosion is serious.

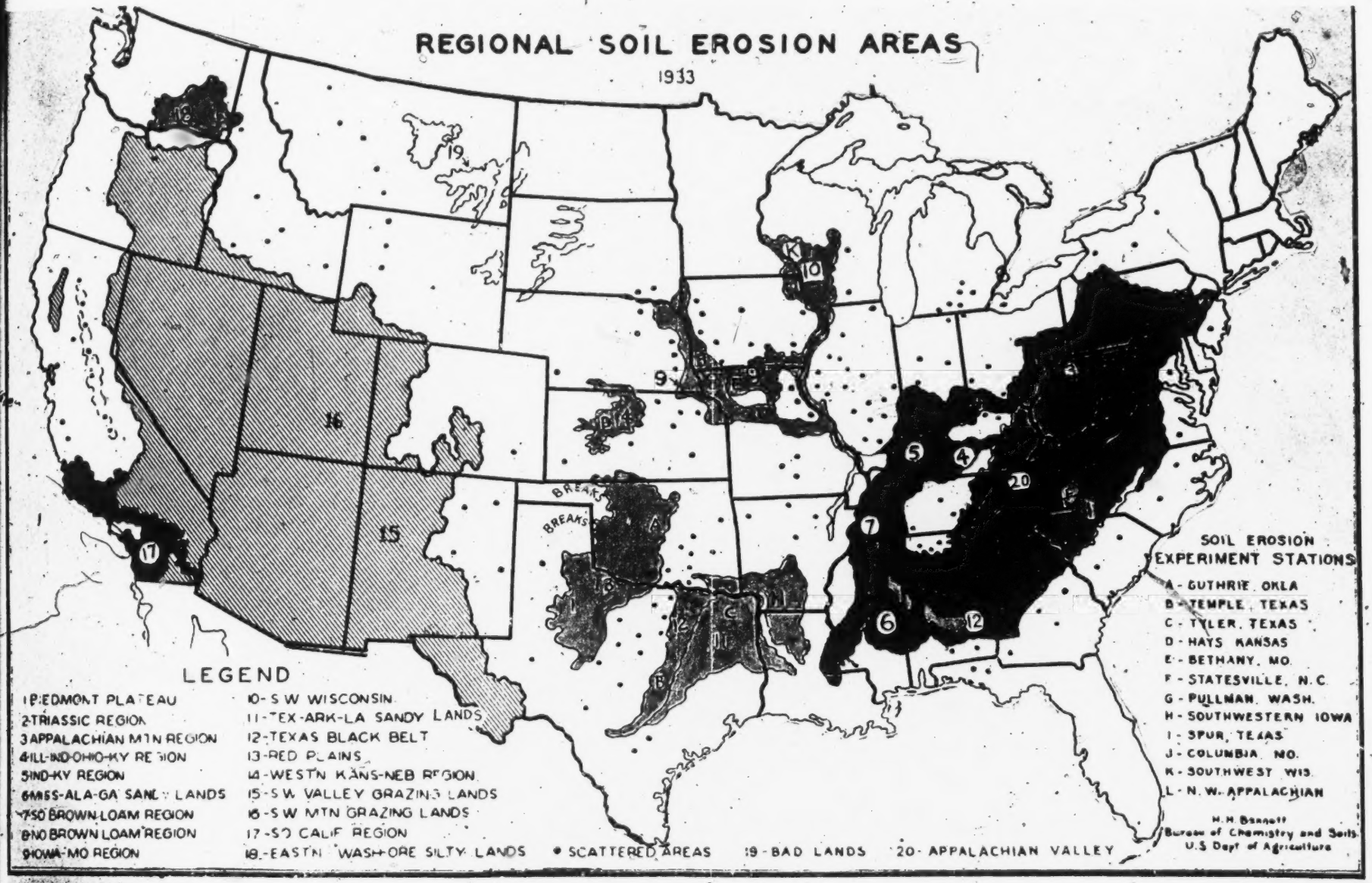
Taking these sheets with typewritten numbers ranging from four to 13, on page four are shown two pictures illustrating the effect of soil erosion on land. These pictures are from the Red Plains Soil Erosion Farm Station at Guthrie, Oklahoma. On page five is the picture showing soil erosion on the Houston black clay soil which appears

widely in Texas, and some in Alabama. On page six is a picture from Southeastern Washington, showing erosion conditions. On page seven is a picture showing a badly eroded field of comparatively gentle slope. This could have been rather easily prevented by the growth of cover crops. On page eight are two pictures from Virginia. These are relatively steep slopes which have been badly gullied. Had they been devoted to close growing crops and more or less fertilized with phosphorus that erosion would never have taken place. Page nine shows land in Northwestern Mississippi with the result of erosion. On page 10 there are two pictures showing erosion on the Shelby soil. On page 11 are pictures of soils which have been eroded, and although the slopes are fairly steep this land could have been saved had it been sufficiently fertilized and devoted to close growing crops. On page 12 are pictures from Pennsylvania. The upper picture is of an over-grazed pasture; that is, this sloping land has been left in pasture, which is desirable, but the pasture was not sufficiently fertilized or well cared for with the result that the grasses were not growing closely enough together to prevent erosion. The lower picture is of very good soil, but the land has been unprotected with vegetation with the result that stones have accumulated on the surface and made a stony soil which cannot be cultivated. On page 13 are two pictures from Georgia. The upper picture showing the extreme type of gully erosion. Here again, the top soil has been removed, and the only way to get such a soil into agricultural use is by fertilization and the cultivation of close growing crops. These examples are typical of the problems faced in our work. (At this point there was offered in evidence as Defense Exhibit No. 51 the sheets No. 4 to No. 13 inclusive referred to by the witness. These exhibits have been omitted from this narrative.)

This report entitled "First Report of the Committee on Soil Erosion, United States Department of Agriculture" is an advisory report of the several men who have been assigned to study the problem. In the back is a map showing the general regional areas of soil erosion. The document entitled "Soil Erosion and Survey of Oklahoma" is a survey made by the experiment station of the Oklahoma Agricultural and Mechanical Arts College in cooperation with the Department of Agriculture. These documents represent the general type of studies based on the soil survey reports. This map entitled "Regional Soil Erosion Areas" is similar to the map which is in the back of that report, except that this has been colored. This gives the list of experiment stations. The pink color on the map represents investigational work already established (In reproduction this is light shading); the blue, additional areas most urgently in need of work (In reproduction this is dark shading). The Tennessee Valley area is shown in blue on the map. (At this point there was offered in evidence as Defense Exhibit No. 52, the map above referred to, a reproduction of which exhibit appears upon the opposite page.)

These six graphs and four sheets of photographs numbered from 39 to 56 inclusive are typical of the results of the experiments and investigations in this field. The black area on sheet 39, for example, shows the loss of soil and the white portion shows the amount of run-off. Continuous cotton culture is probably the most favorable situation for erosion. With cotton alone you have much greater erosion than with the other crops. When rotation is resorted to the erosion fades to a very little. I call attention to the fact that according to these pictures grass is as effective as forests in the control of run-off. (At this point the exhibits above referred to were offered in evidence as a group as Defense Exhibit No. 53, a reproduction of which exhibit appears upon succeeding pages.)

Defense Exhibit No. 52.



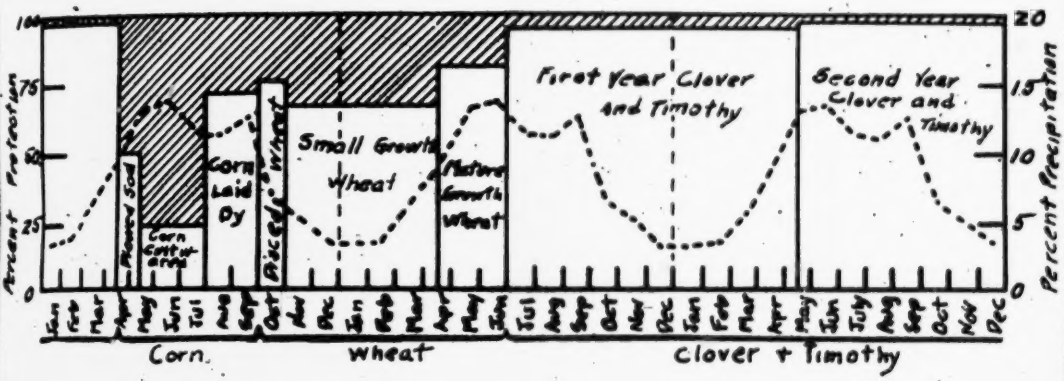
Investigational work already established but requiring expansion

Additional areas most urgently in need of work

Exhibit I-17

Defense Exhibit No. 53.

GRAPHIC INDICATION OF APPROXIMATE PROTECTION AGAINST EROSION AFFORDED BY A 3-YEAR ROTATION OF CORN, WHEAT, CLOVER AND TIMOTHY IN NORTHERN MISSOURI AS PLOTTED AGAINST THE AVERAGE RAINFALL FOR FORTY YEARS AT BETHANY (80 PERCENT PROTECTION BY CROPS).



ESTIMATED DEGREE OF PROTECTION

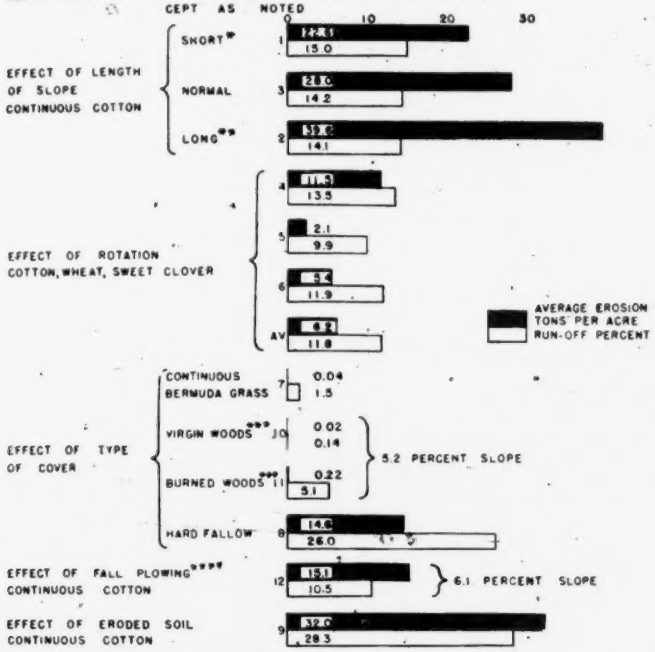
UNPROTECTED

RELATIVE PRECIPITATION EXPRESSED AS PERCENT OF TOTAL

Defense Exhibit No. 53A.

GUTHRIE, OKLAHOMA

FOUR YEAR SUMMARY OF SOIL AND WATER LOSSES FROM CONTROL PLOTS RED PLAINS SOIL EROSION EXPERIMENT STATION 1930, 1931, 1932, AND 1933 VERNON FINE SANDY LOAM 7.7 PERCENT SLOPE EXCEPT AS NOTED AVERAGE RAINFALL 32.92 INCHES EXCEPT AS NOTED

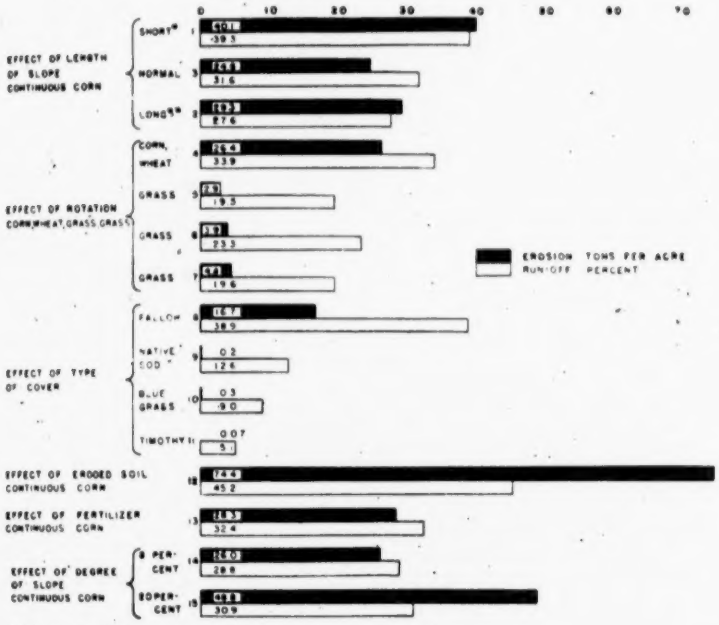


* 6' X 36.3' 1/200 A.
** 6' X 145.2 1/50 A. ALL OTHERS 6' X 72.6' 1/100 A.
***ESTABLISHED APRIL 15, 1930 AVERAGE RAINFALL 32.51 INCHES
****ESTABLISHED 1931 AVERAGE RAINFALL 32.51 INCHES

Defense Exhibit No. 53B.

ZANESVILLE, OHIO

SOIL AND WATER LOSSES FROM CONTROL PLOTS JULY 1, TO DECEMBER 31, 1933 NORTHWEST APPALACHIAN SOIL EROSION EXPERIMENT STATION MUSKINGUM SILT LOAM 12 PERCENT SLOPE EXCEPT AS NOTED
RAINFALL 18.43 INCHES

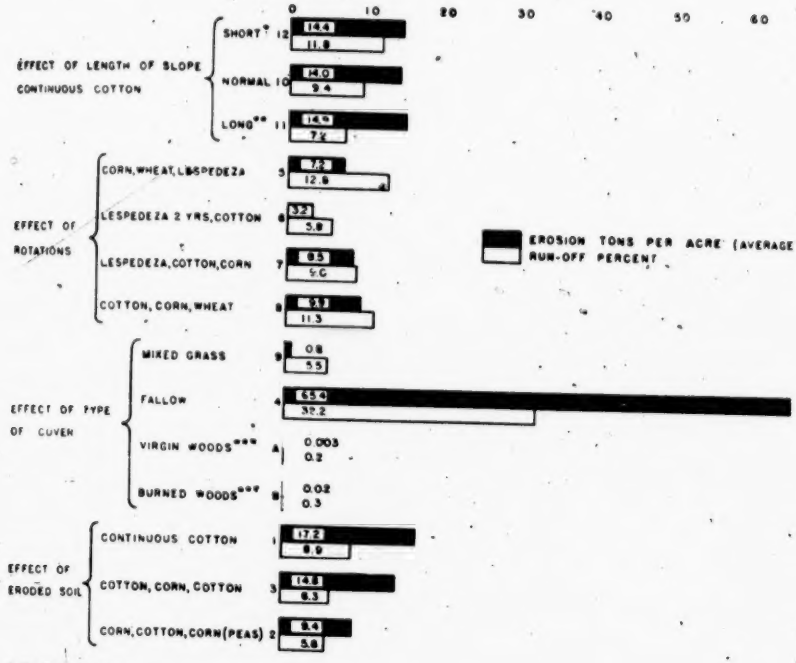


* 6' X 36.3' 1/200 A
** 6' X 145.2' 1/50 A ALL OTHERS 6' X 72.6' 1/100 A.

Defense Exhibit No. 53C.

STATESVILLE, NORTH CAROLINA

THREE YEAR SUMMARY OF SOIL AND WATER LOSSES FROM CONTROL PLOTS
CENTRAL PIEDMONT SOIL EROSION STATION 1931, 1932, AND 1933 CECIL SANDY
CLAY LOAM 10 PERCENT SLOPE AVERAGE RAINFALL 43.02 INCHES EXCEPT
AS NOTED

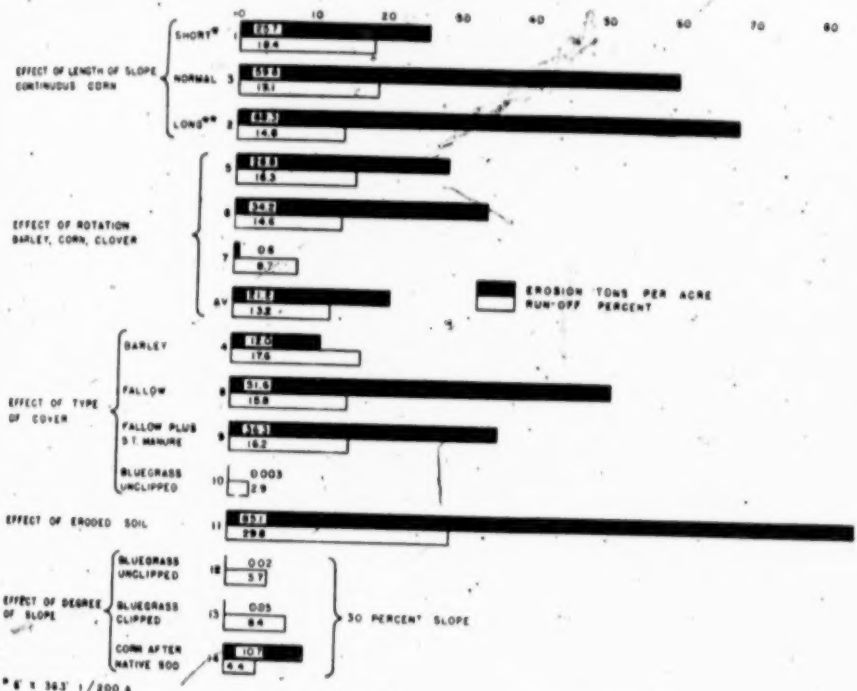


* 6' X 36.3' 1/200 A.
** 6' X 145.2' 1/50 A ALL OTHERS 6' X 72.6' 1/100 A.
*** ESTABLISHED 1932 AVERAGE RAINFALL 42.36 INCHES

Defense Exhibit No. 53D.

LA CROSSE, WISCONSIN

ONE YEAR SUMMARY OF SOIL AND WATER LOSSES FROM CONTROL PLOTS UPPER MISSISSIPPI VALLEY SOIL EROSION EXPERIMENT STATION 1933 CLINTON SILT LOAM 16 PERCENT SLOPE EXCEPT AS NOTED
RAINFALL 29.11 INCHES

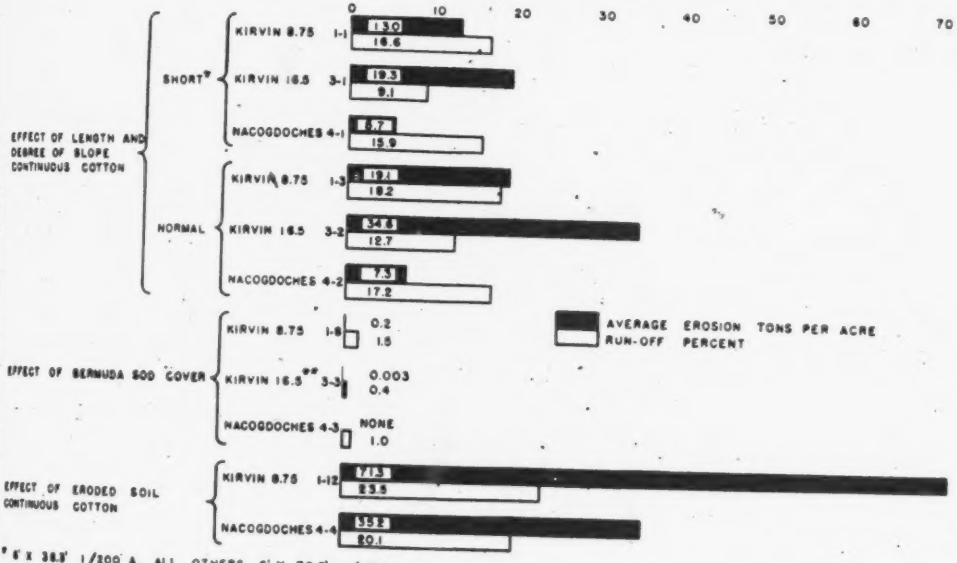


* 6' X 36.3' 1/200 A
** 6' X 145.8' 1/80 A ALL OTHERS 6' X 72.6' 1/100 A

Defense Exhibit No. 53E.

TYLER, TEXAS

COMPARISON OF THE EFFECT OF DEGREE AND LENGTH OF SLOPE AND SOIL TYPE ON SOIL AND WATER LOSSES
KIRVIN FINE SANDY LOAM 8.75 PERCENT SLOPE 1931, 1932, AND 1933 AVERAGE RAINFALL 42.31 INCHES
KIRVIN FINE SANDY LOAM 16.5 PERCENT SLOPE 1932 AND 1933 AVERAGE RAINFALL 48.86 INCHES
NACOGDOCHES FINE SANDY LOAM 10 PERCENT SLOPE 1932 AND 1933 AVERAGE RAINFALL 46.28 INCHES



* 6' X 36.3' 1/200 A. ALL OTHERS 6' X 72.6' 1/100 A.
**ESTABLISHED 1933 RAINFALL 48.91 INCHES

Defense Exhibit No. 53G.

Exhibit IV-6. Gully control—Bethany Soil Erosion Experiment Station. Shelby silt loam, 1930

BEFORE

Gully H—shows gully as typical of those developing on this soil—prior to the installation of control measures

Exhibit IV-6. Gully control—Bethany Soil Erosion Experiment Station. Shelby silt loam, 6-22-34

AFTER

Gully H—three years after setting wire checks, plowing down sides and setting trees. Such gullies are typical on the Shelby loam

Defense Exhibit No. 53H.

Exhibit IV-8. Strip cropping on Shelby loam soil (slope 4-5%). Bethany Soil Erosion Experiment Station, 6-22-34. Field L. looking up one of the draws or drainage-ways that function not only in carrying water down the slope from above the established strips but also from the strips themselves as it is delivered from them to such a natural channel-way as a result of the slight grade down the slope on which they are established. The strips themselves are each 115' wide and are used for a 3-year rotation of corn, oats and clover laid out on a modified contour with permanent meadow below and an irregular area of alfalfa above.

Defense Exhibit No. 53I.

Exhibit IV-7. Strip cropping on Shelby loam soil (slope 4-5%). Bethany Soil Erosion Experiment Station, 6-22-34. Field L, looking south from the highway across one of the sodded draws or drainage-ways that functions not only in carrying water down the slope from above the established strips but also from the strips themselves as it is delivered from them to such a natural channelway as a result of the slight grade down the contour on which they are established. The strips themselves are each 115′ wide and are used for a three-year rotation of corn, oats and clover, layed out on a modified contour with permanent meadow below and an irregular area of alfalfa above.

In the Tennessee Valley there have been about 39 soil surveys. This document entitled "Soil Survey of Hardin County, Tennessee, United States Department of Agriculture" is typical of the various surveys. (At this point the survey above referred to was offered in evidence as Defense Exhibit No. 54. This exhibit has been omitted from this narrative.)

Upon **Cross-Examination** the Witness Testified as Follows:

We have made detailed surveys of approximately half of the arable part of the United States. I would not be able to give you in feet per second the velocity in a flowing stream that would carry the silt of that stream in suspension. The ratio of the velocity of the stream and the volume of silt varies approximately as the sixth power of velocity of the carrying capacity of the water.

L. O. FIPPIN,

Called as Witness on Behalf of the Defendants, Testified Upon **Direct Examination** as Follows:

I am by profession a soil technologist. At the present time I am soil consultant with the Tennessee Valley Authority. I graduated from the Ohio State University in 1900 in Agronomy, and had a year of special work at Cornell University. In the latter part of 1900 I entered the United States Department of Agriculture in the Bureau of Soils. For several years I was engaged as a field assistant in making soil surveys and reports. For several years I was a professor of soil technology at the New York State College of Agriculture at Cornell University. Then I was Director of experiment stations in the Republic of Haiti. From 1931 to 1932 I was with the Federal Farm Board, and from then until 1934 I was with the Agricultural Adjustment Administration. I recently made an investigation of soil conditions in the Tennessee Valley. The

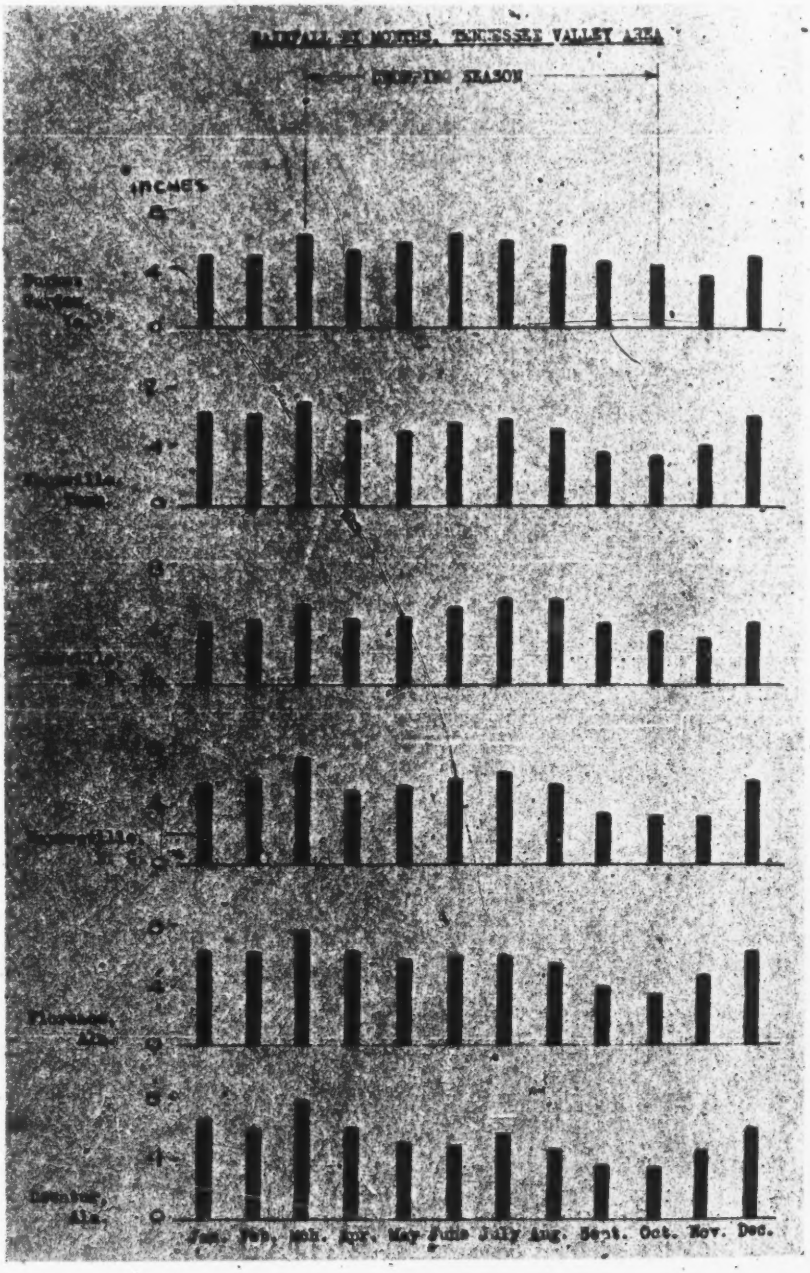
three types of soil erosion are sheet, shoe string and gully. I have here two charts: one representing the normal section of soil, and the other the three types of erosion. (At this point there was introduced as evidence Defense Exhibit No. 55, the chart entitled "Normal Section of Soil", and as Exhibit No. 56, the chart representing the types of erosion, which have been omitted from this narrative.)

I have some photographs that illustrate these types of erosion. The first represents a corn field which has been subjected to fairly heavy rain. There are no gullies, but just a general sheet movement that cuts into the soil. The next is a photograph that shows the destructive action of sheet erosion. The next photographs show land that has been farmed and treated in a certain way continuously for 29 years. The part in the foreground has been kept bare, while the plot beyond has been kept continuously in grass, and the plots on the right and left have been kept in seed. If you look at that field you would not recognize that there was any sheet erosion, but the retention of soil by the roots of the crop prove it over a period of years, and that is what is happening on practically every acre of farm land. These are the three photographs illustrating the effect of sheet erosion. (At this point the three photographs above referred to illustrating the testimony with respect to the effect of sheet erosion were offered in evidence as Defense Exhibit No. 57, which exhibit has been omitted from this narrative.)

The next two photographs represent shoe string erosion. You can see how the little gullies are dominant, and you can see the subsoil sticking through, as expressed by the difference in color. (At this point the two photographs above referred to as illustrating the effect of shoe string erosion were introduced in evidence as Defense Exhibit No. 58, which exhibit has been omitted from this narrative.)

The next two photographs illustrate the more extreme stage, the gully stage. (At this point the two photographs

Defense Exhibit No. 61.



referred to as representing the effect of gully erosion were introduced in evidence as Defense Exhibit No. 59, which exhibit has been omitted from this narrative.)

There are four primary factors that determine the degree of erosion and all of these factors are prevalent throughout the Tennessee Valley. Those are rainfall, surface slope, character of the soil, and the nature of the plant covering. The nature of the plant covering is the deterrent factor. The rainfall in the Tennessee Valley is relatively high. I have a map which I have prepared from the data of the United States Weather Bureau. The red coloring represents a rainfall of over 80 inches per year; the blue, a rainfall of from 60 to 80 inches; the green, a rainfall of from 45 to 50 inches, and the yellow under 45 inches. (At this point the map referred to by the witness entitled "Distribution of Average Annual Rainfall, Tennessee River Basin" was introduced in evidence as Defense Exhibit No. 60, which exhibit has been omitted from this narrative.) The important thing with respect to rainfall is not only the total, but the distribution through the season and the intensity. I present this graph made from the same data showing the monthly distribution of rainfall in the vicinity. The month of March is a particularly high rainfall month, and that is an important fact, because at the end of winter the soil has been loosened by frost and is especially susceptible to erosion. (At this point the chart referred to by the witness entitled "Rainfall by Months, Tennessee Valley Area Cropping Season" was introduced in evidence as Defense Exhibit No. 61, a reproduction of which appears upon the opposite page.)

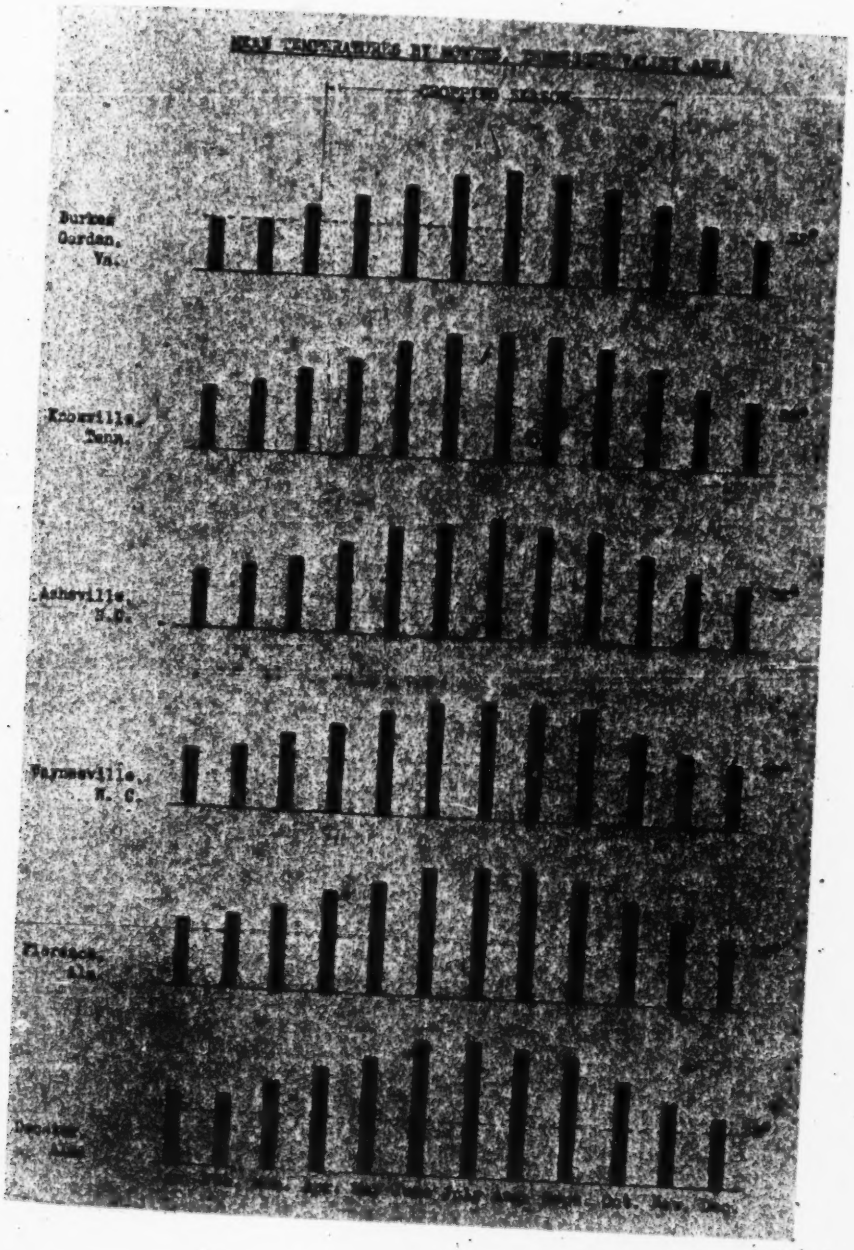
I also present this chart showing the monthly temperatures in the Valley. In the northern part of the Valley, we are just on the verge of having the land freeze and remain frozen for a considerable period, which is a protective factor, but further south, the short periods of cold do not freeze the land, but they do loosen

it and make it more susceptible to erosion. (At this point the chart referred to by the witness entitled "Mean Temperatures by Months, Tennessee Valley Area Cropping Season" was offered in evidence as Defense Exhibit No. 62, a reproduction of which appears upon the opposite page.)

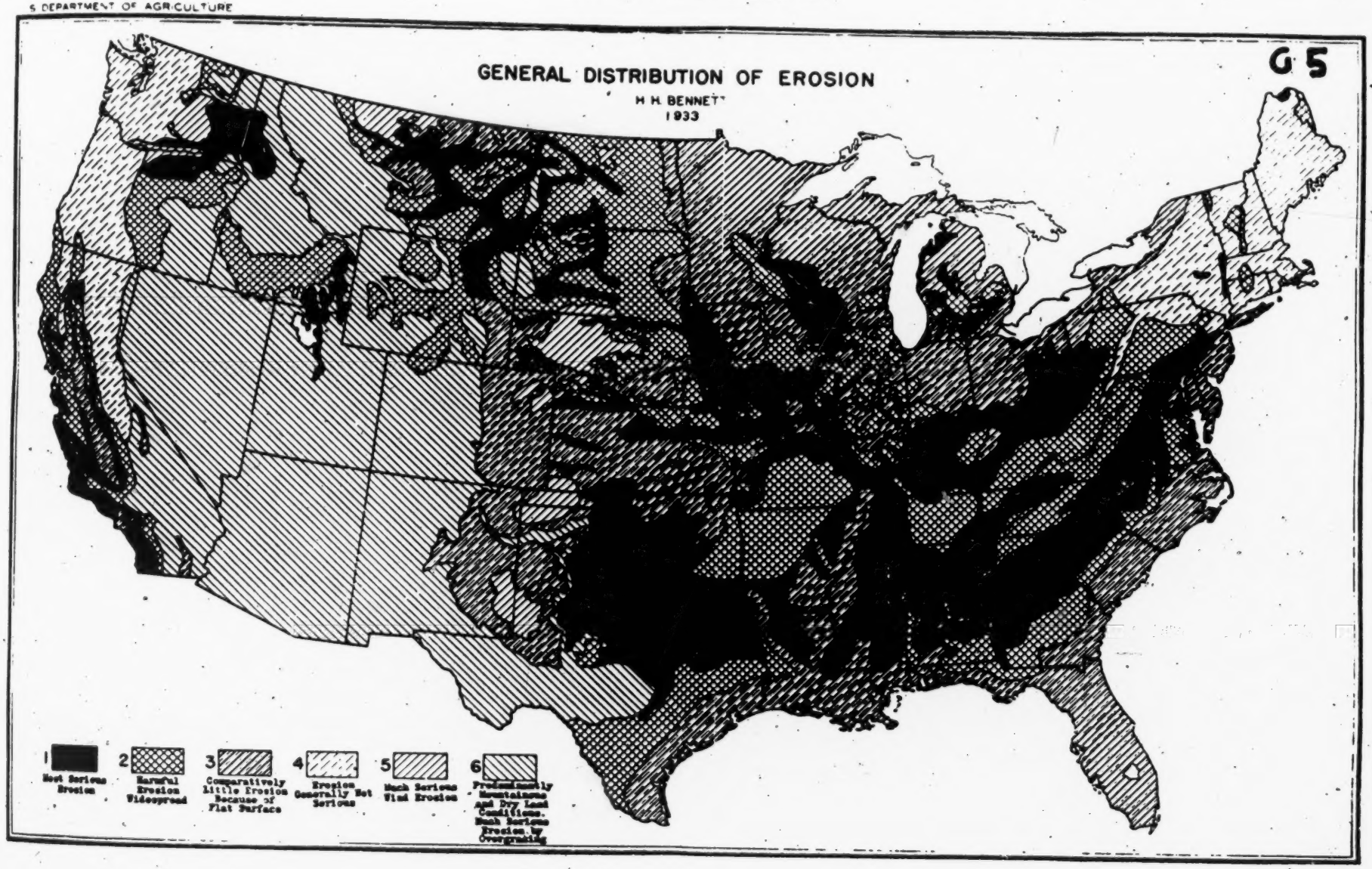
In the Tennessee Valley there is almost no level land. It is predominantly sloping. In the Valley there is considerable steep and stony mountainous land which is extremely subject to erosion. There are also silty clay loams, which are also susceptible to erosion. The third type of soil is made up of fine sands and silt, which is particularly susceptible to erosion. The crop cover in the Tennessee Valley is not adequate. About 44% of the land in the Valley is in some kind of farm or open land, which cannot be put into trees and therefore must be utilized in some kind of crop cover. The acute cover problem is in the farm area and due to natural conditions that cover is defective. At least 95% of the cultivated land in the area is subject to serious erosion, ranging all the way from the loss of two or three inches on the mild slopes under the present farming conditions, to the total loss of the soil over considerable areas. Here is a map of the United States prepared by Mr. H. H. Bennett of the Soil Erosion Service, which appears in an official document and shows the classification of the land area of the United States in terms of the extent of erosion. The black area represents the most serious erosion condition. Practically all of the Tennessee Valley is included in that section. (At this point the map referred to by the witness entitled "General Distribution of Erosion, H. H. Bennett, 1933" taken from House Document 395, 73d Congress, 2d Session, opposite page 44, was introduced in evidence as Defense Exhibit No. 63, a reproduction of which exhibit appears upon the opposite page.)

Here is a series of photographs which I took on the

Defense Exhibit No. 62.



Defense Exhibit No. 63.



1,800 mile tour that I made in the Valley. This first photograph is one taken along the main highway just beyond Kingston, Tennessee. You can see the deep gullies in that hillside which was, a few years ago, smooth farm land. The next four or five illustrate serious gullies and sheet erosion in the region west of the river. The next is a photograph taken near Tazewell showing the subsoil sticking through. Here is a picture taken just east of Athens in Limestone County, Alabama. Each of these photographs has a legend upon the back that shows the locality referred to and there are 17 of them. (At this point the 17 photographs just referred to by the witness were offered in evidence as a group as Defense Exhibit No. 64, which exhibit has been omitted from this narrative.)

Here is a map prepared by me showing the various stages of erosion in a locality in the Valley selected as being truly representative. The white areas on the map are areas which may be said not to be subject to serious erosion. The blue area represents lands which are almost universally in timber so that it is not much of a problem; the red area represents land which has lost already from three to as much as six inches of its topsoil. You can see what a large proportion of the Valley that embraces. The purple color represents land totally ruined. (At this point the map referred to by the witness was introduced in evidence as Defense Exhibit No. 65, which exhibit has been omitted from this narrative.)

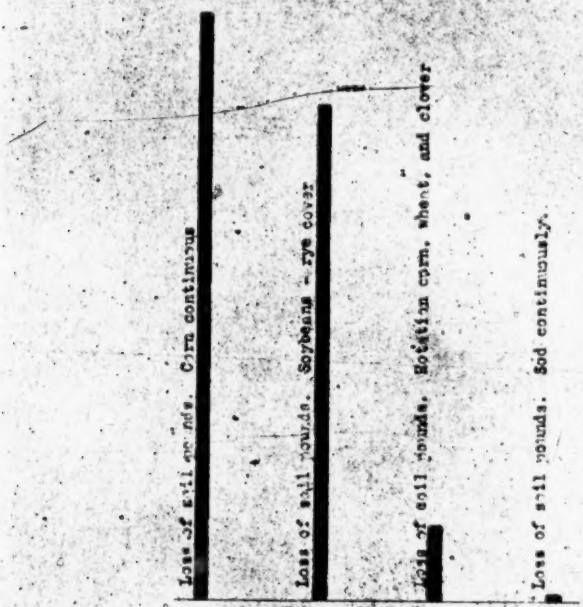
In the course of my investigations I have assembled experimental data showing the relative effect of different crops and cropping systems in controlling erosion. I have this series of 17 or 18 graphs which illustrate the various factors. These graphs show that the steeper the land the greater the run-off, the greater the loss of soil, and particularly that exposure of the land causes a great run-off of water. Any kind of crop is a protective factor. Cultivated crops are the most acute problem. Sod crops reduce the

loss to a very large extent. The rotation of tilled crops with corn and hay crops is very efficient in cutting down the losses. The graphs illustrate that farm crop covers can be made so effective as to practically nullify the process of erosion. (Graphs referred to by the witness were introduced in evidence as defense Exhibits No. 66 through No. 77, inclusive; reproductions of these exhibits appear consecutively upon succeeding pages, with the exception of Exhibit No. 76, which has been omitted from this narrative.)

Plants act to enmesh the soil and serve as a binder. They also produce vegetable matter which tends to form a mat on the surface as a further protection and they loosen the soil and increase the power of absorption. There is a striking example of what happens when we take away just one factor in erosion, namely, the crop cover. That is represented by the Ducktown Basin. All of the vegetation was killed in that region by copper mining operations. This photograph begins at the edge of that area. It shows how the mountain region has been protected by the trees in the upper left hand corner of the photograph. (At this point the photograph referred to by the witness was offered in evidence as Defense Exhibit No. 78, which exhibit has been omitted from this narrative.) We then see as we come nearer how the trees were killed and how erosion began to eat into the hills in the second photograph. The third photograph shows the land as bare as a desert. The fourth photograph shows the condition a little more completely. The streams draining out of that region are loaded with sediment and 15 miles down one of those streams is a reservoir. It is estimated that that reservoir in 18 years has lost 21% of its effective capacity. (At this point the photographs referred to by the witness were introduced in evidence as Defense Exhibits No. 79 to No. 85 inclusive. Exhibits 79, 80 and 81 have been omitted from this narrative; reproductions of Exhibits 82, 83, 84 and 85 appear consecutively upon succeeding pages.)

Defense Exhibit No. 66.

Crop	[illegible]	Soil eroded annually in tons per acre
Corn	Continuous	12.632
Soybeans	Rye as cover	10.640
Corn	Rotation corn wheat, clover	1.638
Sod	Continuous	0.123

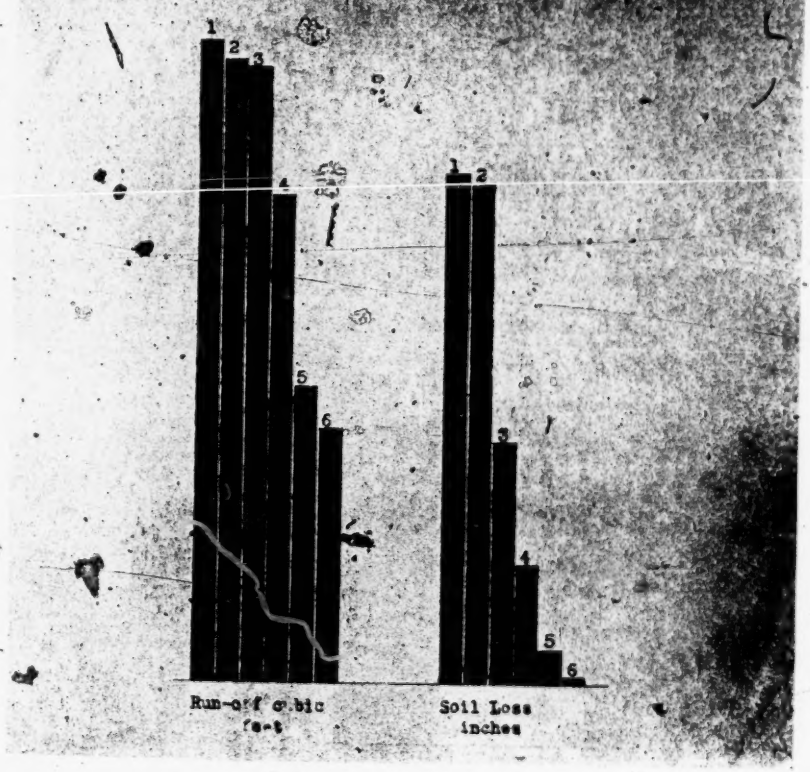


Defense Exhibit No. 67.

Soil Treatment or Cropping Series	Average Per cent Run-off	Total pounds soil eroded per acre	Total surface inches soil eroded	Ins. required to remove surface 7 inches
1. Spaded 4", cultivated	31.29	247.3	1.731	84
2. Spaded 8", cultivated	28.34	214.3	1.499	98
3. No crop and no spade	45.92	207.8	1.454	97
4. Continuous corn	27.38	106.5	0.745	84
5. Continuous wheat	25.19	39.9	0.279	150
6. Rotation corn, wheat and clover	14.14	13.7	0.096	437
7. Continuous Blue Grass	11.65	1.7	0.011	3247

Defense Exhibit No. 68.

System of cropping and tillage	Total cubic feet of run-off	Soil loss in tons per acre	Soil loss in inches
1. Plowed 4". Fallowed	645,000	865	6.1
2. Plowed 8". " "	630,000	575	4.0
3. Continuous corn	620,000	280	1.93
4. Continuous wheat	490,000	150	0.98
5. Rotation: corn, wheat, clover.	300,000	38.0	0.27
6. Continuous Blue Grass	256,000	4.75	0.033

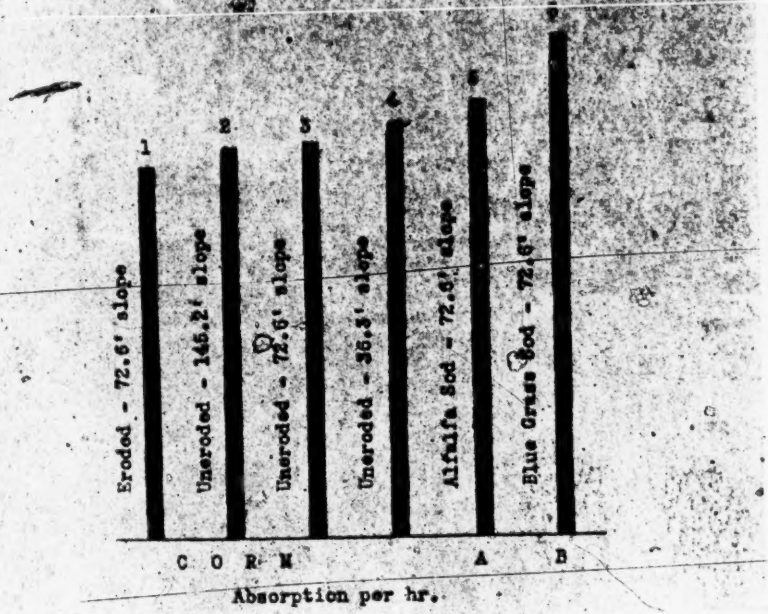


Defense Exhibit No. 69.

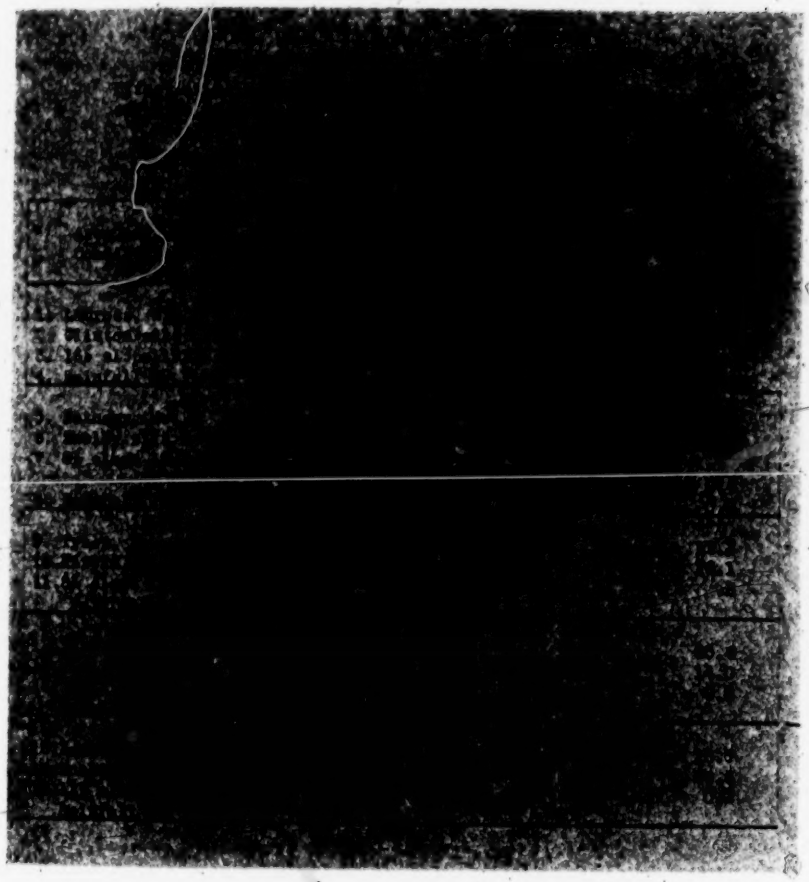
MISSOURI VALLEY LOESS

Effect of crop and degree of soil erosion on absorption of rainwater. Results erosion control investigations 1932 and 1933. Marshall silt loam soil. U. S. Bureau Chemistry and soils, by C. E. Musgrave. Trans. Am. Geophysical Union, Fifteenth Annual Meeting, 1934.

Crop Treatment	Length slope, ft.	Average Duration Run, min.	Absorption per min.
1. Corn (eroded to subsoil)	72.6	4	1.44
2. Corn	145.2	3	0.77
3. Corn	72.6	4	0.96
4. Corn	36.3	3	0.67
5. Alfalfa	72.6	44	0.98
6. Blue Grass	72.6	39	0.94



Defense Exhibit No. 70.



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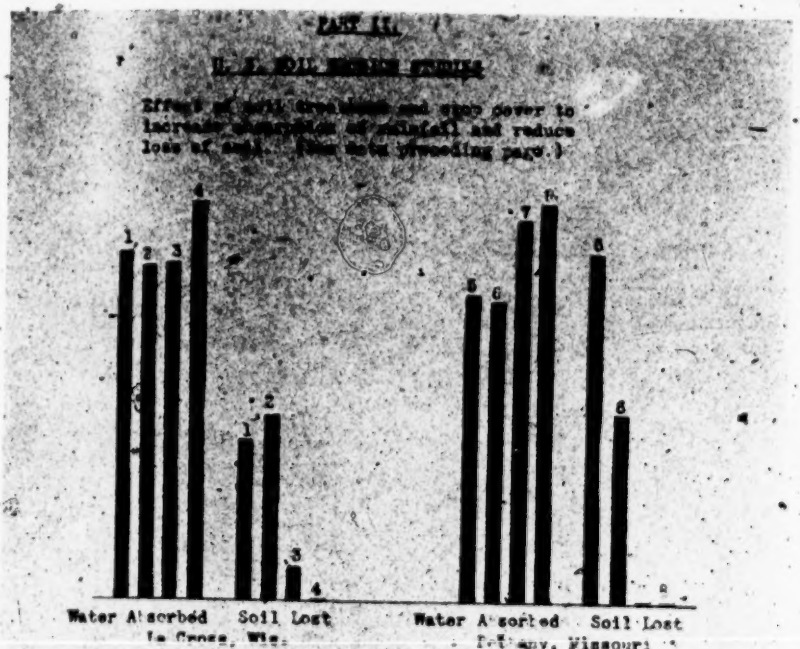
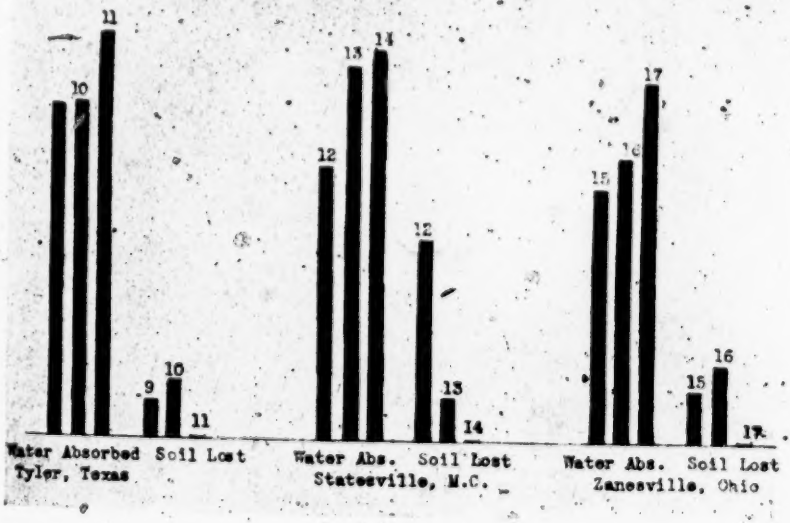




Defense Exhibit No. 72.

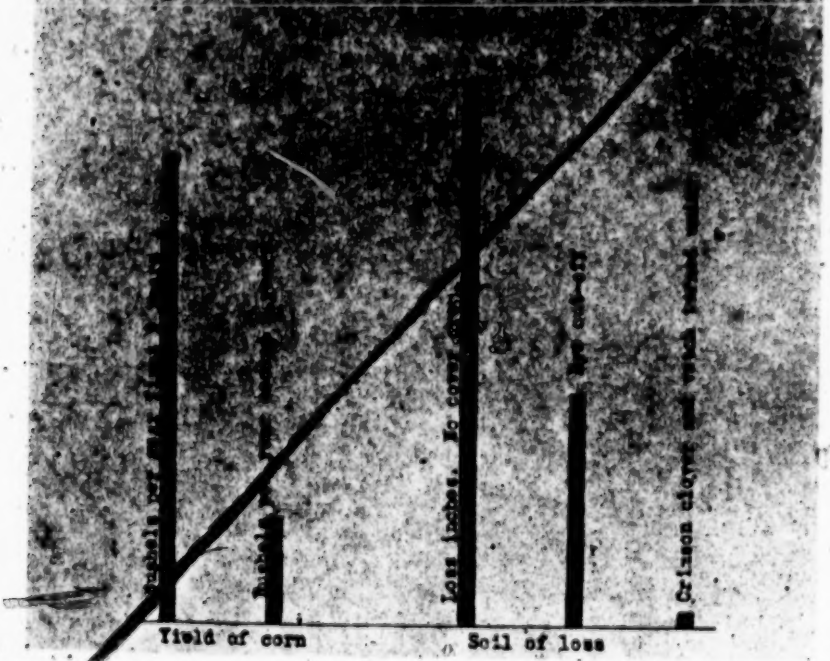
BLACKSBURG, VIRGINIA

Relation of plant cover to washing of Hagerstown loam, limestone soil. Agr. Exp. Station Farm. (Unpublished material by E. [illegible])

18 years cultivation 5.8 [illegible]
annual rainfall 43.72 inches

Cover	Total inches soil removed 18 years	[illegible]
1. [illegible]	5.7	[illegible]
2. [illegible]	[illegible]	[illegible]
3. [illegible]	[illegible]	[illegible]

Average yield corn	[illegible]
1st 9 yrs.	[illegible]
2nd 9 yrs.	[illegible]

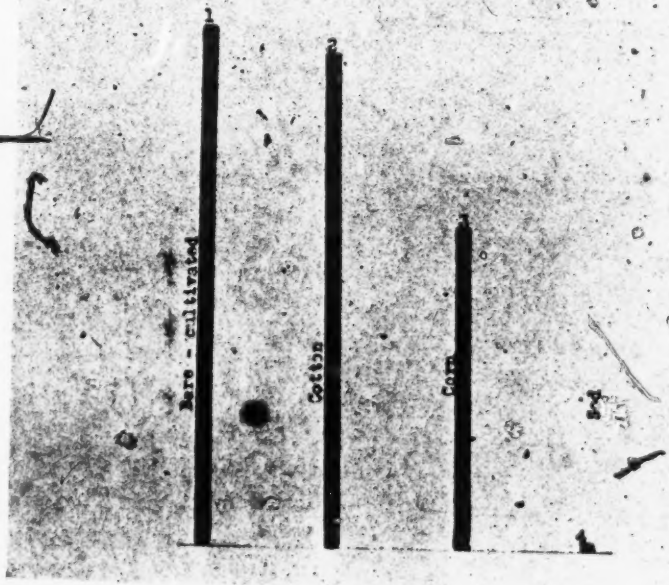


Defense Exhibit No. 73.

NORTH CAROLINA

Effect of cropping system in reducing loss of soil material by erosion. Annual loss in tons for 3 years on 9 per cent slope under rainfall of 41 inches.
Report by H. F. Miller of No. Science,
No. 5, Vol. 73, page 83. January 23, 1931.

Crop	Tons soil lost per acre per year
1. Bare cultivated	21
2. Cotton	20
3. Corn	13.5
4. Sod	.42

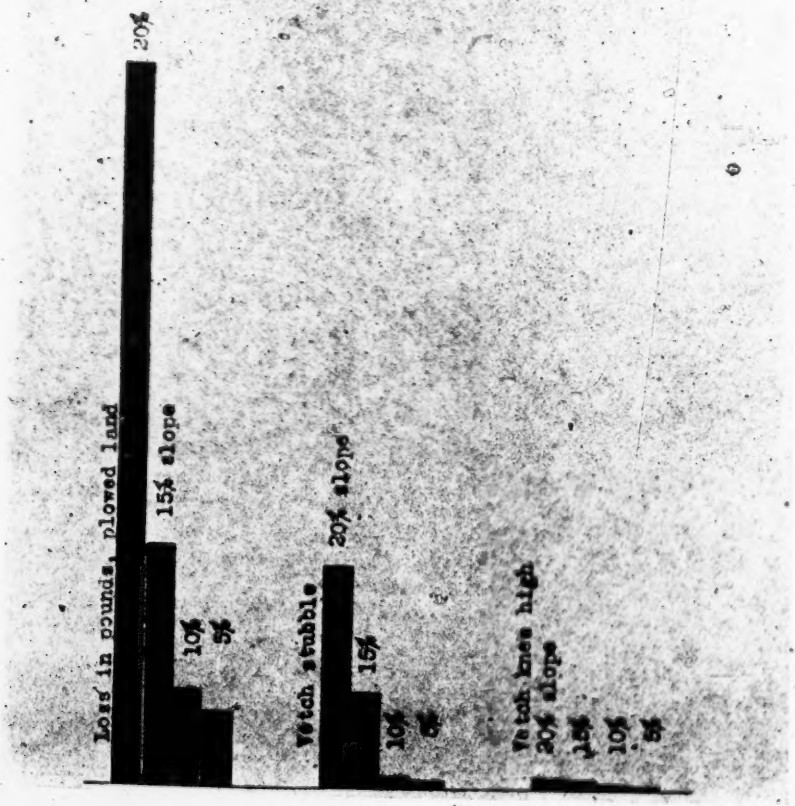


Defense Exhibit No. 74.

AUBURN, ALABAMA

Effect of crop cover in preventing loss of soil on different slopes. Red Piedmont Clay at Agricultural Experiment Station, 1929. One inch water applied in 8½ minutes.

Cover	Slope in per cent			
	5	10	15	20
	Loss in pounds soil per acre			
Plowed	11995	2427	6239	19000
Vetch stubble	193	238	2393	5823
Knee high vetch	65	82	268	284

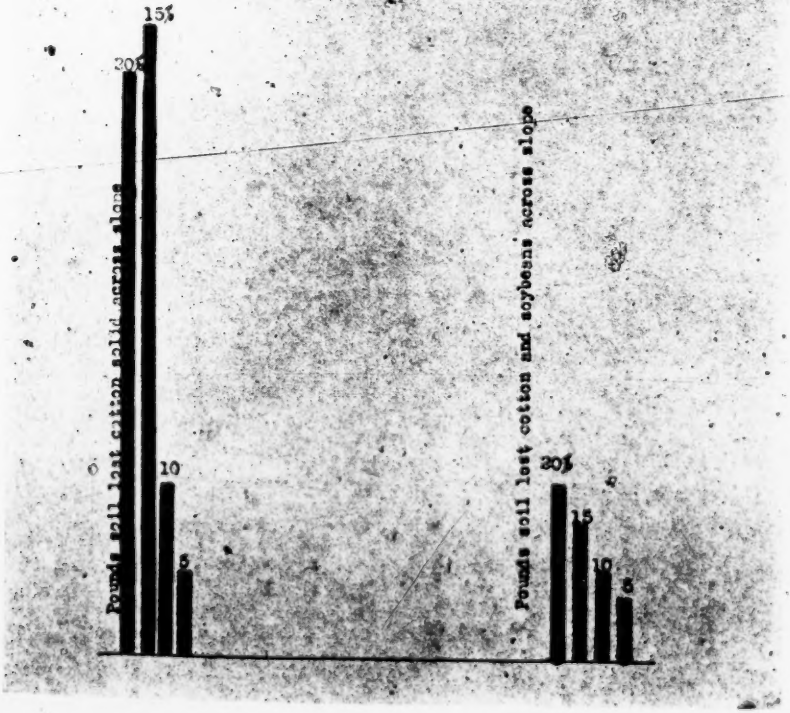


Defense Exhibit No. 75.

AUBURN, ALABAMA

Comparative effect of solid tilled crops planted across slope with alternate 12 feet bands of cotton and soybeans in rows 18inches apart. Soil: Red Piedmont Clay. Rainfall: 13.95 inches. Agricultural Experiment Station.

Method of Planting	Per cent of slope			
	5	10	15	20
	Pounds of soil lost			
Cotton alone	6975	14139	51193	47348
Cotton alternating with soybeans as filter crop	5517	7528	11354	14473



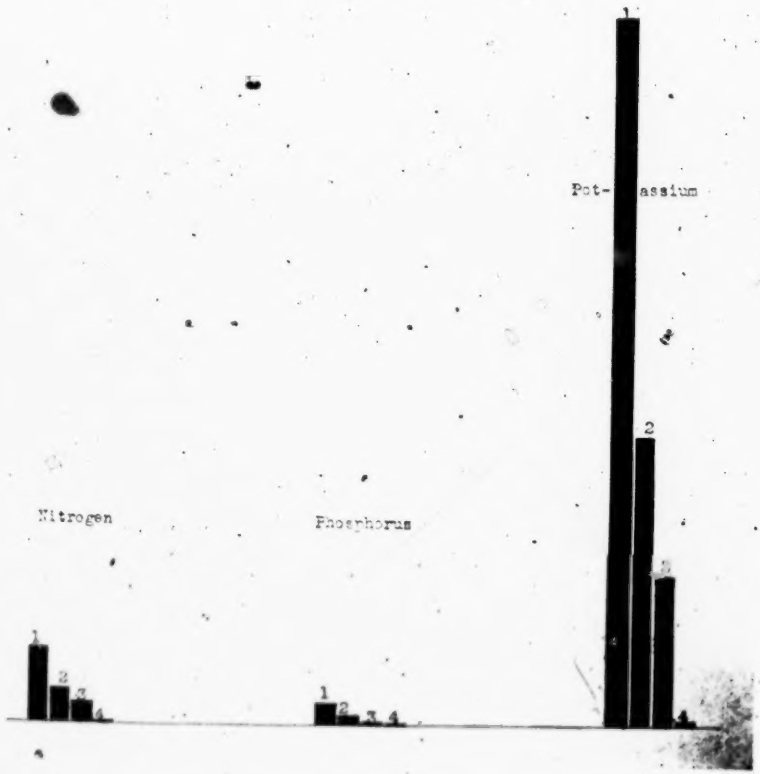
Defense Exhibit No. 77.

COLUMBIA, MISSOURI

Annual loss of plant nutrients in soil removed by erosion under different cropping systems.
Slope: 3.68 per cent.
M. F. Miller, Agricultural Experiment Station, Mo.
Science, No. 5, Vol. 73, p. 83.
January 23, 1931

Average - 13 years

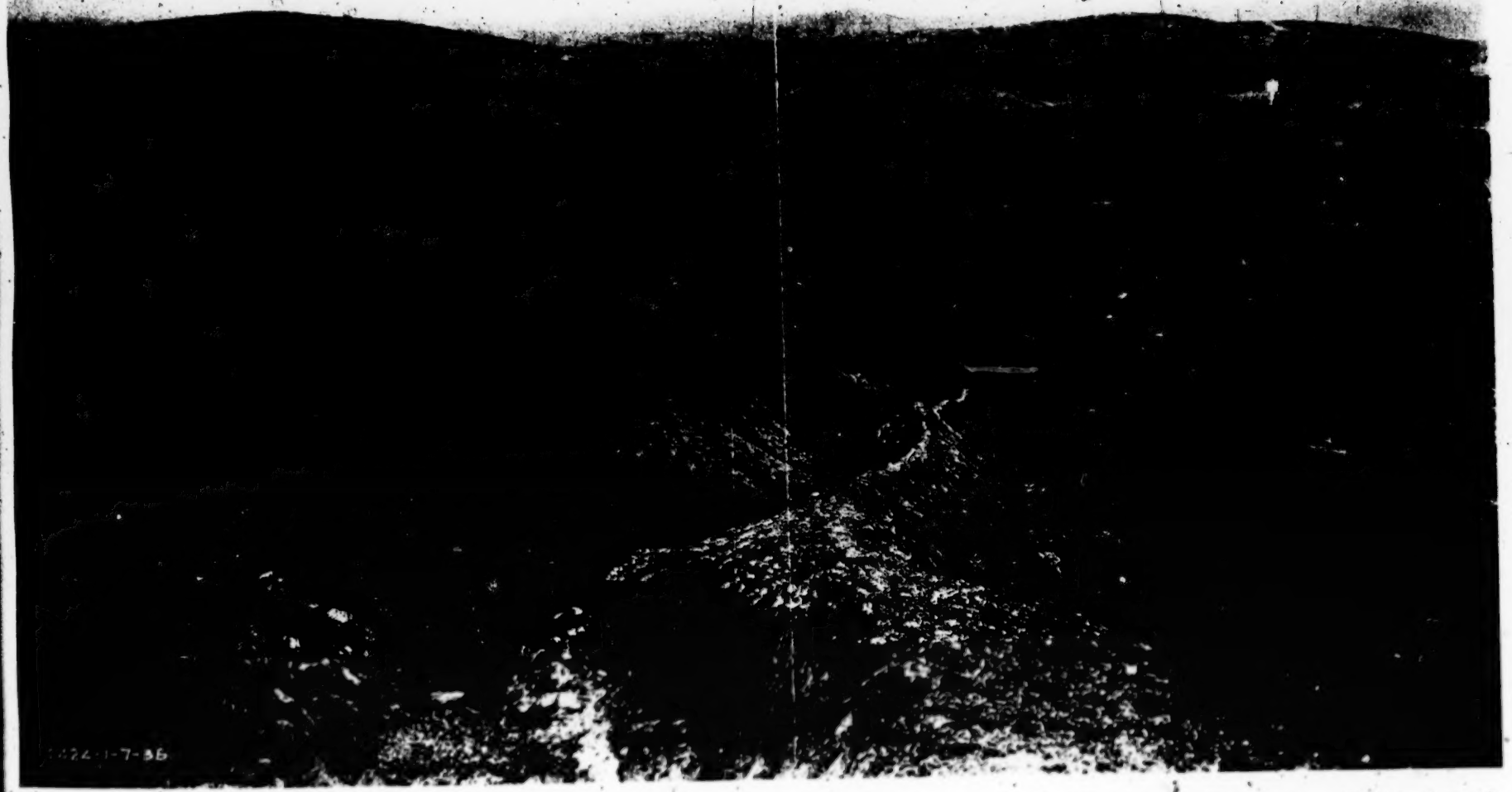
Cropping System	Nitrogen	Phosphorus	Potassium
	Pounds per Acre		
1. Continuous corn	65	18	610
2. Continuous wheat	30	9	250
3. Rotation	18	4	140
4. Sod	1	1	4



Defense Exhibit No. 82.

Ducktown desolation due to destruction of plant cover and active erosion for period of years. Not a plant in sight. A, B and lot of C horizon gone. Mine operations at left result of sulphuric acid fumes released years ago.

Defense Exhibit No. 83.



Absolute destruction of land by erosion following killing of plant cover by sulphuric acid fumes at Ducktown, Tennessee. Gullies 4 to 10 feet deep. Not a plant in sight

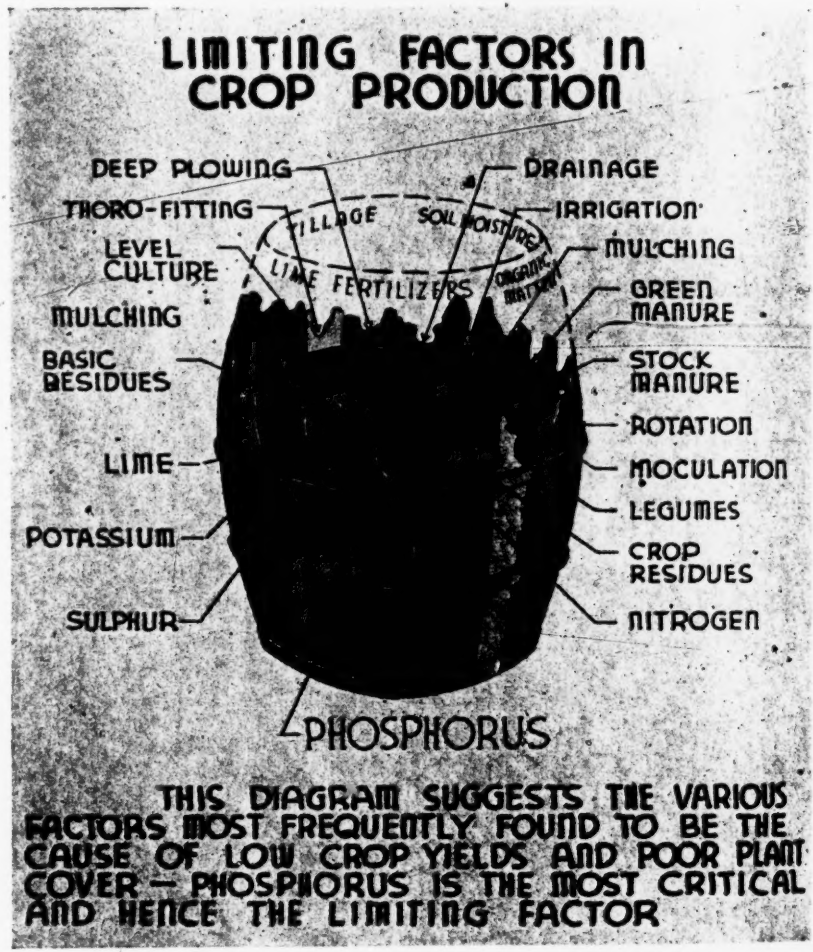
Defense Exhibit No. 84.

Overload of coarse sediments in small stream bed at edge of Ducktown area. Small delta at right. Milder stages of gullies on hills. Two miles west of Ducktown. Route 74

Defense Exhibit No. 85.

250 acres of sediment 5 to 20 feet deep in upper end of Ocoee Reservoir on Toccoa River from Ducktown area in less than five years. 60 miles east of Chattanooga, Tennessee, Route 74 silt and fine sandy loam

Defense Exhibit No. 86.



I have a chart showing the limiting factors in the productivity of the soil and hence, the possibility of obtaining adequate crop cover to protect the soil. This is a barrel and it shows the staves cut down to form various notches. The liquid that the barrel might hold would be no higher than the lowest notch. In the same way, in the soil, the yield of crops can be no higher than the lowest limiting factor. By means of legumes nitrogen can be obtained from the atmosphere, and it is possible for the farmer to be released from that limiting factor. The lowest notch very commonly and generally is phosphorus. (At this point the chart referred to by the witness, entitled "Limiting Factors of Crop Production" was introduced in evidence as Defense Exhibit No. 86, a reproduction of which exhibit appears upon the opposite page.) Almost universally phosphorus is the key element in the production of crop cover to protect the soil and increase its fertility. The fact of a deficiency of phosphorus in the soil of the Tennessee Valley is well supported by the conclusions of the outstanding soil scientists of that region, based upon comprehensive experimental and research data. A rearranged cropping system in the Tennessee Valley, if coupled with the widespread use of phosphorus plant food, would mean that the rough, steep and worn out land could be transferred to timber, thereby protecting it from erosion. The next steepest lands could be put in pasture and the next steepest slopes could be kept in hay and corn so far as possible. Only the smoothest and best land would be used for tilled crops. Legumes would be introduced into the rotation as a cover crop and in order to insure a larger supply of nitrogen. The run-off and erosion would be tremendously reduced. This chart was prepared under my supervision and direction. Starting at the upper left hand corner, we have soil upon which no phosphorus has

been used undergoing erosion. Added phosphorus induces a good plant growth. The writing on the right side of the chart represents my opinion and my testimony. The diagram in the center is a pictorial representation of a cycle or combination of relationships. Speaking of the condition of eroded soil, if we add phosphates to any soils, then we have immediately raised the level of the crop yield. We have made possible the growth of legumes. By the growth of legumes, we have gathered nitrogen from the air. All of that, in turn, comes back to electric power. The cycle is based upon the assumption that the Tennessee Valley Authority has a plan and method actually in operation for manufacturing phosphates by electric power. (At this point the chart referred to by the witness was introduced in evidence as Defense Exhibit No. 87, a reproduction of which exhibit appears upon the opposite page.)

Upon **Cross-Examination** the Witness Testified as Follows:

It does not make any difference where the phosphate comes from. If it is applied it will produce beneficial results. It is true that there is nothing in my testimony that has not been known for generations. It is not new, but it has not been generally understood. In Jefferson County, Tennessee, to which I referred, there is a farm demonstration agent. I should say it is about 50 miles from the University of Tennessee. Dr. Morgan is a member of the Board of the Tennessee Valley Authority and has been for years head of the University of Tennessee.

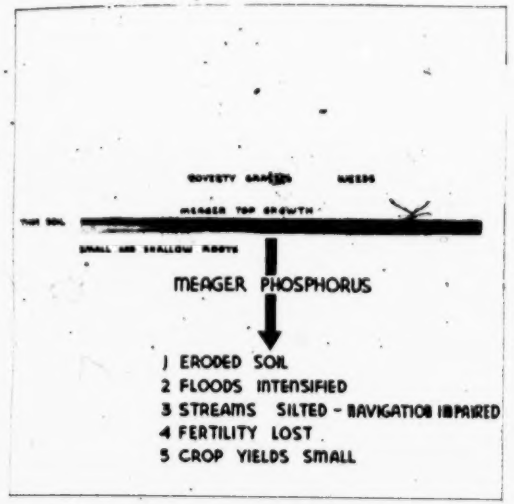
Upon **Redirect Examination**, the Witness Testified as Follows:

The price and the convenience of procuring phosphate fertilizer are factors that have limited the use of phos-

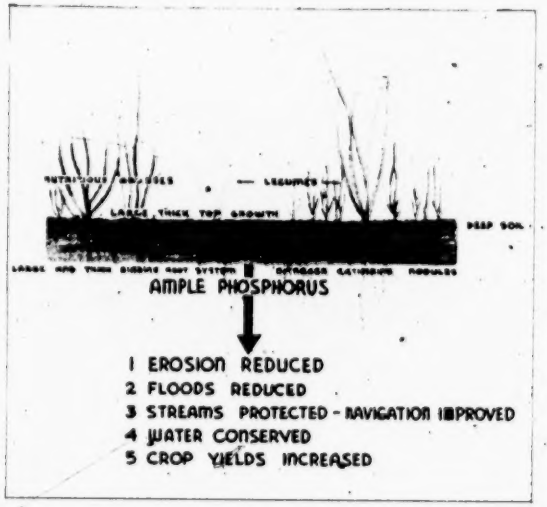
Lack of add
Meager plan
tion and re
cover permi
soil. Exce
destruction
soil erosio
process is
land and th

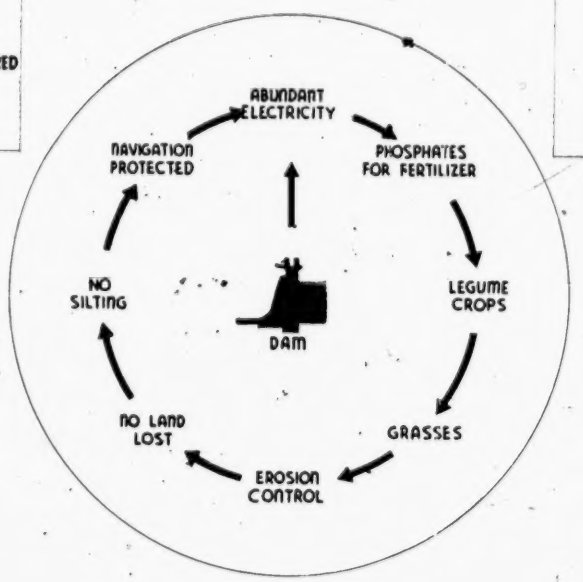
Defense Exhibit No. 87.

WATERSHED PROTECTION PROGRAM THRU ELECTRIC POWER + BASIC DATA BY E.O.FIPPIN



+ ABUNDANT ELECTRIC POWER AND PHOSPHATE MATERIAL WITH LIME =





WRONG

Lack of added phosphorus induces meager plant growth. Meager plant growth causes reduction of water absorption and reduced fertility of the soil. Meager plant cover permits larger runoff and excessive loss of soil. Excessive runoff results in gullies and complete destruction of farm land. High runoff and excessive soil erosion obstruct streams and fill reservoirs. The process is a progressive one for the destruction of farm land and the obstruction of water channels.

RIGHT

Addition of available phosphorus induces abundant plant growth. Abundant plant growth increases water absorption and increases the fertility of the soil. Abundant plant cover greatly reduces runoff and loss of soil. Reduced runoff prevents the formation of gullies and the destruction of farm land. Reduced runoff and reduced erosion keep streams and reservoirs clear of sediment. The soil upbuilding permitted by the available phosphorus is a progressive process. Soil upbuilding through crops culminates in complete protection of streams and reservoirs.

phates in this region. While it is true that in general farmers know something about fertilizer, it is an established fact that the convenience of procuring these materials must be impressed very heavily upon their minds in order to insure its use.

Upon **Recross Examination** the Witness Testified as Follows:

There are farm demonstration agents in most of the counties. Those farm demonstration agents cooperate with the Extension Service of the University of Tennessee. This survey concerning which I have testified was made in January of this year for this hearing, and I took these photographs in preparation of this case. My services have been made available by the Department of Agriculture for the purposes of this hearing. I am not in the standing employ of the Tennessee Valley Authority.

J. C. McAMIS,

called as witness on behalf of the defendants, testified upon **Direct Examination** as follows:

At the present time I am head of the Agricultural Division of the Tennessee Valley Authority. We have discovered that erosion in the Tennessee Valley is primarily on those parts of farm lands that are devoted to cultivated crops. In order to do anything about it, we felt that it was necessary to first interest the farmers in this problem and secure their cooperation. The agencies which are leading farmers in the development of their problems have been enlisted and their cooperation secured in carrying out a soil conservation program. The agricultural colleges representing in these states the United States Department of Agriculture were called together and consulted with in

regard to this problem. We have had a number of conferences with them. Those conferences began in about October 1933 and resulted in the execution of contracts between the Tennessee Valley Authority and the agricultural colleges in each of the seven states in the Tennessee Valley. An example of these contracts is this one with the Alabama Polytechnic Institute under date of February 13, 1934. All of the land in this area with the exception of one or two localities appeared to be in need of phosphorus. The experiment stations of these colleges are equipped with facilities for experimentation, including laboratories and test plots. The first step in the program was the signing of this contract, so as to engage the cooperation of these experimental agencies in testing the relative value and effect of the new forms of fertilizer materials. (At this point copy of the contract above referred to was introduced in evidence as Defense Exhibit No. 88. A copy of this exhibit has been omitted from this narrative, since the substance thereof appears in witness' testimony).

A further contract was executed with these agricultural colleges for the use of their extension agencies, including the county agricultural agents in each county. Typical of these contracts is this one executed between the Tennessee Valley Authority and the University of Tennessee. (At this point copy of the contract above referred to by the witness was introduced in evidence as Defense Exhibit No. 89. A copy of this exhibit has been omitted from this narrative since the substance thereof appears in witness' testimony). Under this contract the colleges have agreed to use the facilities and personnel of their extension agencies throughout the Valley in demonstrating on the lands of practical farmers the use of fertilizers produced by the Ten-

nessee Valley Authority, in readjusting farming systems so as to control erosion. Administrative machinery has been provided by which the work of the various agricultural colleges, the United States Department of Agriculture and the Tennessee Valley Authority may cooperate in carrying out this research and demonstration program. This arrangement is formulated in writing in a document entitled "Statement and Memorandum of Understanding Between United States Department of Agriculture with the Tennessee Valley Authority and Certain Agricultural Colleges." (At this point the copy of the memorandum of understanding referred to by the witness was introduced in evidence as Defense Exhibit No. 90. A copy of this exhibit has been omitted from this narrative since the substance thereof appears in witness' testimony). To be effective these materials must be placed on a type of farm where they will be applied on soils and crops to which the phosphate fertilizer is especially adapted. The first step in this demonstration program is to select a demonstration farm in each well defined community, where a program and a plan will be worked out which will include the use of this phosphate in the control of erosion. These farms are in the process of being selected by the people in each community, and a plan is being worked out by them subject to the guidance and approval of the County Agricultural Agent and of the Tennessee Valley Authority. It is our purpose to place this phosphate fertilizer on those farms and to measure the results. We expect in that manner to increase the general demand for fertilizer and to extend this program so as to include all the farmers in the Valley who wish to participate. On the basis of past experience, we have every reason to believe that the demonstration method will be effective. An analysis will be

made of the present set-up of the farm for comparison of what the effect will be of the use of these phosphates. On those farms there will be a decided increase in the acreage of soil protecting crops. The two purposes are to improve and maintain the fertility of the soil, and the prevention of erosion. Legumes will operate to restore the nitrogen element to the soil, and legumes and other thick growing crops prevent erosion. In this area, each acre of land, speaking generally, should have in the neighborhood of 16 pounds of P 2-0-5 phosphate plant food per year. According to that rate of application there will be an annual need for approximately 140,000 tons of 40% triple super-phosphate for about 7,000,000 acres of land in the Valley. That does not include land which is normally in cotton, corn or tobacco. It will probably be advisable to make an initial application of some two or three times that amount. That does not need to be kept up at that rate. Judging by the results that have been obtained by the Agricultural Adjustment Administration acting through these county agents, I have confidence in their ability to carry out this program. We will get the phosphate fertilizer from Nitrate Plant No. 2 at Muscle Shoals.

Upon **Cross-Examination** the Witness Testified as Follows:

I went with the Tennessee Valley Authority in September, 1933. The program that I have described was gradually developed after I went there. It was generally known that erosion was general on farming lands and not on forest lands. I do not believe that the seriousness and extent of the problem is generally recognized either by farmers or by some experts. There is no agreement by which we have undertaken to supply fertilizer to the farmers; there are

no contracts as to that. It is very probable that after the fertilizer is available every farmer in the Valley will be given an opportunity to demonstrate this fertilizer on his own farm. We are beginning on an initial demonstration of one farm in each well-defined community. The fertilizer will be provided to the farmers by his paying the freight, and it will be applied in a system of agriculture under an agreement that he will adopt a sound cropping system that will control erosion on that land. The payment for the fertilizer is to be freight only. There are different forms of phosphate, and the experiment stations are making tests of the different forms that are being manufactured in the experimental plants at Muscle Shoals. The Tennessee Valley Authority is now making phosphate. Some of that phosphate will be placed on government lands. We have already sent some fertilizer to Norris for use in this program. None of the agreements for the community demonstration farms have been signed at the present time. That budget item of something over $1,000,000 for revenue from the sale of fertilizer is just a transfer of accounts from my department to the fertilizer department. It is the understanding that we are to pay them for the fertilizer. I am not clear as to the basis per ton. Possibly Dr. Curtis may be able to answer that. It is a mere bookkeeping entry.

Upon **Redirect Examination** the Witness Testified as Follows:

We have not adopted any plan for the commercial sale of fertilizer.

HARRY A. CURTIS,

called as witness on behalf of the defendants, testified upon **Direct Examination** as follows:

I am a chemical engineer and am at the present time Chief Chemical Engineer of the Tennessee Valley Authority. I have charge of the chemical engineering activities of the Authority. I was graduated from the College of Engineering at the University of Colorado in 1903 and became a member there. I received the degree of Master of Arts in 1910. I went to the University of Wisconsin in 1913 and received the Doctors degree there; returning to the University of Colorado as a member of the faculty. In 1917, I entered the World War and was assigned to the Nitrate Division of Ordnance, and spent part of my time at Muscle Shoals in connection with the nitrate plants. After the armistice I became Chief of one of the laboratories of the Ordnance Department at Arlington Farms, Virginia. I helped to organize a fixed nitrogen research laboratory in Washington. In 1919 I went to Northwestern University as a member of the faculty. In 1920 I became Chief Chemist for the International Coal Products Corporation. Later I was appointed General Manager of the Clinch Field Carbon Coal Corporation. In 1923, I undertook the direction of a survey of nitrogen resources for the Department of Commerce. Later I went to Yale University as Professor of Chemical Engineering. In 1926, I was a member of the Muscle Shoals Inquiry, appointed by President Coolidge to consider the problem of Muscle Shoals. In 1928, I represented the United States Department of Agriculture at the International Nitrogen Congress. In 1930, I returned to Washington as Chairman of one of the divisions of the National Research Council.

At the time of its creation, Nitrate Plants No. 1 and No.

2 in the neighborhood of Muscle Shoals were transferred to the Tennessee Valley Authority. Those plants were constructed during the World War for the manufacture of munitions. Nothing has been done with Nitrate Plant No. 1. We have rehabilitated certain of the facilities, such as railroad lines, turbines and electric services at Nitrate Plant No. 2. We have installed two electric furnaces for the production of phosphoric acid, along with the accompanying plant facilities to supply these furnaces with raw material to convert phosphoric acid into phosphate fertilizer in order to cheapen fertilizer. Such parts of the plant as are not used are maintained in a stand-by condition under the terms of the Act. We are considering the installation of two additional electric furnaces with the attendant equipment. Since the World War there have been great improvements in the art of fixing nitrogen. There is no real opportunity for the Tennessee Valley Authority to lower the price of nitrogen products in fertilizer. There is an opportunity to make a very considerable technical progress with phosphorus. In the plans of the Agricultural Division, it is indicated that large quantities of phosphorus fertilizer will be required in the soil conservation and flood control program. Phosphate rock is one of the ores that is present in the Tennessee Valley relatively close to the Shoals. It has been recognized for a long time that if a concentrated fertilizer could be produced as economically as low grade fertilizer, it would be possible to deliver the fertilizer to the farm at a considerably lower cost. So far as the grade of rock is concerned, the cheaper the power the lower the grade of rock that you can smelt in the electric furnace. We are using in our plant a somewhat lower grade of rock than has been used heretofore. The process briefly is as follows: Phosphate

rock, silica and coke are smelted in the electric furnace, the electric current supplying the heat. Under these conditions there is a chemical reaction as a result of which phosphorus, along with other gases, is forced from the furnace. The balance of the material becomes slag, which is tapped from the furnace. The phosphorus usually is burned. The resulting product, when treated with water, forms a liquid phosphoric acid. A portion of the phosphate rock is ground fine and mixed with phosphoric acid to produce the product ordinarily known as super-phosphate. Approximately 10,000 KWH of electric energy per ton of phosphorus is required in this process. Phosphorus has for a long time been produced by the electric furnace method. That method has been used in producing phosphatic fertilizer to a very limited extent. In general, the electric power available has not been cheap enough to make that method attractive in competition with the older method. In a set-up like ours where you have power that is not being used and a nitrate plant lying idle, fertilizer can be produced by this method a great deal cheaper. Taking the actual amount of power that has been used in the past three months, and calculating from that the amount required to produce a ton of super-phosphate, the electric power consumption required to produce 210,000 tons mentioned by Mr. McAmis would be approximately 630,000,000 KWH per year. 55.000 KW, which is the total firm capacity of Wilson Dam, used continuously 24 hours a day, 365 days in the year, would amount to about 480,000,000 KWH, as compared with the 630,000,000 KWH that is required for the production of the 210,000 tons of phosphate. The production of the phosphatic fertilizer to be economical should be a continuous 24 hour process.

I have about 50 chemists, chemical engineers and drafts-

men at work carrying on a research program directed towards using new types of fertilizer. We are also investigating the chemistry of cyanamide. Since Nitrate Plant No. 2 is a cyanamide plant that product could be produced very cheaply there. At present cyanamide is objectionable as a fertilizer. If we could discover mechanical means of removing the objectionable characteristics, it is possible that we could supplement our phosphate fertilizer program with nitrogen from that source. If we should succeed in that, a substantial amount of additional electric energy would be required, as the cyanamide process consumes a great deal of electric energy.

Upon **Cross-Examination**, the Witness Testified as Follows:

In getting at the total quantity of energy that might be required for 210,000 tons of super-phosphate, I took the total energy used by the plant and divided it by the total amount of super-phosphate that we produced. That gave me the unit per ton. The estimated capacity of each furnace is 24 tons of P 2-0-5 per day per furnace. The two furnaces now in operation will not produce the 210,000 tons of super-phosphate referred to. The standard grade super-phosphate is 46 to 48%. We are producing 43-45%. Each of the furnaces is capable of producing about 20,000 tons of triple super-phosphate per year per furnace. In converting the furnaces to this process, we took the old furnace entirely out right down to the foundation. Ten of the old furnaces are left. There is an existing over capacity for any existing market for either agricultural or trade uses of nitrogen. I do not believe that it would be economical to operate that plant for the manufacture of nitrogen, although it is the largest and one of the newest

cyanamide plants in the world. If, as the agricultural program develops, it appears that nitrogen is needed, and we have power that would otherwise be wasted, we might under those circumstances operate the plant for the production of nitrogen. The two additional electric furnaces contemplated, would be for the production of phosphorus. There is a large existing excess of capacity for the production of ordinary super-phosphate so far as the present market is concerned. There are a number of plants making triple super-phosphate; some of them in this area. Up to this time the farmer has shown a great disinclination to use highly concentrated fertilizer. Being concentrated material, more care must be taken in its use. It will require some development of agricultural machinery in order to use this more concentrated material satisfactorily. I know of no process that is on the whole cheaper and more economical and more satisfactory than the ordinary one of allowing the material to dry and cure. The process which we are using is in itself an old process on which no patents exist. Our patent attorney has studied the question and is of the opinion that with one possible exception, we are free of patent infringements. I have not been able to obtain the price figures on the production of phosphatic fertilizer by the commercial plants. So far as cost is concerned, I have taken the attitude that such power as we need to make the fertilizer is the first demand upon the Authority. The power is there, just as the nitrate plant is there, and we propose to use both, since they were going to waste previously. I have only followed the matter far enough to be very sure that having a plant and having power, we can produce the fertilizer for our own purposes far cheaper than we can buy it. We hope, eventually, to be able to compare the cost of one process as against

another. We are setting up books to that end. No definite arrangement has yet been made as to the charge that shall be made to the fertilizer division for power. We are discussing that matter now. Our manufacturing has not proceeded to a point where we have anything like accurate costs. It is well known in industry that you can not arrive at reasonable cost figures in such a period of time as we have been operating.

Mr. McAmis has been talking to me about a distribution plan ever since I came to the Tennessee Valley Authority in the fall of 1933. So far as that budget figure of $1,340,000 reflected as a credit to the fertilizer division is concerned, I suspect that that was based on a big wild guess. We are in the development stage, and so far as budgets are concerned, if they ask me what I am planning to do for the next three or four or five months, I can make a decent sort of guess, but when they ask me what I am going to do a year from now, I set down a few figures and probably multiply them by two and tell them that that is what it is going to be. That is the way with these estimates. I don't recall that that item was based on any estimate that I gave to the Authority. It is in the category of things that I have just described. We have not determined the basis per ton of fertilizer that we are going to charge the Purchasing Department. I am not aware of any plan by which any revenue would be derived from the public by the sale of fertilizer. I have been advised of the plan of making the fertilizer available to all farmers in this area who would pay the freight and enter into the necessary agreements. That is the program that Mr. McAmis has submitted. I have nothing to do with it. I make the fertilizer and Mr. McAmis distributes it. I have installed the equipment for ammoniating fertilizer. Mr. McAmis

thinks he may need some. I am prepared to produce it if he does. I think the recovery factor of P 2-0-5 from the phosphate rock is about 75%. We are using on the average a rock of 67 or 68% DTL. The Authority has recently acquired approximately 14,000 acres containing phosphate rock in the Tennessee district. Any electric furnace operation requires some dilution with silica flux unless the silica is carried in the phosphate rock itself. Theoretically, the process takes two parts of P 2-0-5 derived from the electric furnace, with one part derived from the rock.

I am not engaged in any yardstick proposition whatever. I am not trying to show the fertilizer people how to carry on their business. I am carrying on certain developments and have set up a system so that I and they, if they please, will know what it costs, and if there is merit in it they can do likewise. So far as the Tennessee Valley Authority is concerned we are disregarding investment, carrying charges and depreciation because the power and manufacturing facilities are there waiting to be used. In case we should want to determine operating costs, I have had an independent engineering firm design a plant corresponding with the one we have, starting with the cotton patch and the railroad track running by it. We want all the information that would serve in arriving at a cost estimate. I think that it would be possible to determine the comparable cost of production of the fertilizer that we are turning out.

Upon **Redirect Examination** the Witness Testified as Follows:

The difficulty in using the concentrated fertilizer isn't half as great as persuading the farmer to buy it. There is no serious difficulty in mixing it. The phosphate deposits

which we have leased from the owners were not being used. We have leases in Maury County, Perry County and Giles County. Immediately after the World War a Mr. Glasgow, who was one of the assistants to the Secretary of War, Mr. Baker, studied the problem of trying to do something with these nitrate plants at Muscle Shoals, and there were many discussions, at some of which I was present. There was finally evolved the plan of operation which I understand was set out in a letter to Congress from the Secretary of War, which was made a matter of record in this case.

MAJOR WILLIAM H. CROM

Called as Witness on Behalf of the Defendants Testified Upon **Direct Examination** as Follows:

I am a Major in the Air Corps, now connected with the office of the Assistant Secretary of War, Washington, D. C. I have been engaged in procurement planning for some eight years. That consists in making plans to secure the equipment and materials that we will need in the event of another war. Under Section 5a of the National Defense Act, the Assistant Secretary of War was given the mandate to prepare plans for the mobilization of industry, and for the procurement of equipment and supplies in the event of a major emergency. His office includes the planning branch in which there are several divisions, one of which, the Commodity Division, is under my charge. The preparations of the War Department in this respect are outlined in the Industrial Mobilization Plan of 1933 and Text No. 229, which is a supplementary document. A large part of our activity is based upon the assumption that important imports may be cut off in the event of a major war. In making up the lists of equipment, we do not confine our-

selves to munitions. We try to include those things which the nation itself will need in carrying on its normal life. We are especially interested in two groups of materials, one of which we call "critical war materials" and the other "strategic war materials." "Critical materials" are those of which we ordinarly have enough, but which require very close control during a major war to prevent serious shortages. "Strategic materials" are those the supply of which is largely dependent on sources outside of the United States. The great peace acid is sulphuric acid, while the great war time acid is nitric acid. No country has sufficient capacity to make nitric acid to supply its war time needs. All of the explosives have a nitrogen base. Nitric acid is a step in their production and is used in enormous amounts. The fixation of nitrogen is the first step in the production of nitric acid. Abrasives are used in the production of many articles of equipment which the War Department must have. We want great quantities of abrasives available to our contractors in the event of war. Aluminum is very valuable, and the air craft industry is dependent upon it and its alloys. Chlorine is the base of all of the poison gases. If the situation permits us to use poison gas, we will require considerable amounts. Magnesium has two different uses. It is the base for the lights in our landing flares, and as an alloy metal it is being alloyed with aluminum. Refractories are absolutely necessary in the lining of furnaces which the steel industry will need to prepare the steel for the War Department. We must insure that our contractors, in the event of war, will have plenty of it. All of the items that I have mentioned are on the list of "critical materials." The most important material in the manufacture of explosives is nitrate in some form or other. The principal inorganic compound made from nitric acid

is ammonium nitrate. The present plans of the Commodities Division count on Nitrate Plant No. 2 for 110,000 tons of ammonium nitrate per year in the event of war. If that plant will produce that amount annually, it is a useful national defense asset regardless of the process. The plans of the War Department call for the use of phosphorus in the event of war. There was a great increase in its use during the last war, and in any future war its use will probably be much greater. The production of 10 or 15,000 tons of phosphorus per year at Nitrate Plant No. 2 would undoubtedly be valuable. In time of war, if there is an increased demand for a particular commodity, and the productive capacity is unable to meet that demand, it is necessary to divert it from other uses to war uses. If diversion were necessary, it would be more desirable to divert the use of phosphorus which was being used as a soil erosion preventative, rather than that which was being used in commercial fertilizers. The electric furnaces at Nitrate Plant No. 2 are, of course, valuable national defense assets. If those furnaces are under government control, when the needs arise, it is possible without regard to commercial contracts to put them quickly into the production of the required articles. If there developed a deficiency in any one of these materials that I have mentioned during the war, and that deficiency could be filled by the use of these furnaces, they would be valuable and useful as a national defense asset.

Upon **Cross-Examination** the Witness Testifed as Follows:

I have been in charge of making preparation for commodities in the case of war for about a year. I was assistant for about a year and a half before that. The matter of provision for war is a special assignment of the Assistant

Secretary of War. He made an annual report a short time ago in the preparation of which I participated. I have in my records the name of a concern in the Birmingham district which has produced phosphorus and can produce it in large quantities. If it has promised to supply the entire amount which the United States may desire in case of war, the difficulty is that neither that firm nor we ourselves know exactly how much we will want. I do not believe that what is being done at Nitrate Plant No. 2 with respect to the electric furnaces will in any way affect the ability of that plant to produce nitrates. I agree that there are several more economical ways to produce nitric acid at the present time than at Nitrate Plant No. 2, but I am not at all concerned with the question of cost. All I want is the capacity. The War Department recognizes that one of the large sources of capacity for the manufacture of nitrogren is the by-product of coke ovens. In time of war the demand for those articles for which coke is essential is very greatly speeded up.

Electricity is an important enough commodity to have a separate division for its study. If 20 or 30 year fixed contracts for the sale of existing supplies of electric energy could not be broken in the event the power is needed for other purposes in the event of war, such contracts would be detrimental, but I am sure that they would be broken. We have made a power survey of the United States, and, of course, we plan to disrupt the normal life just as little as possible, because morale is a very important factor in war. During the last war there were several power shortages which surprised many of us. Even Niagara, with its power reserves, was short and Pittsburgh was short.

I am familiar with the testimony of the Chief of Ordnance before the Congress of the United States with reference to the nitrate plants. I know that he did say that

the Ordnance Department does not need it and if a nominal bid was received for it he would be willing to let it go. I know that in the annual report of the present Secretary of War the statement is made that the nitrate plant has been made obsolete by the advancement in the art of production. I agree that the method of preparing nitric acid by the oxidation of ammonia is the more economical, but from the national defense viewpoint, if this plant can produce 110,000 tons of ammonium nitrate we are very much interested in it, and the present plans include its use. In 1932, excluding the government nitrate plants, the capacity for fixing nitrogen was 318,600 short tons of nitrogen, speaking only of nitrogen content, and the excess nitrogen 69,000 short tons, giving a total of 387,600 short tons. The Belle and Hopewell plants are included in that. All of the nations have developed tremendous excess in capacity. There have been effective increases in the development of the synthetic process. There is no shortage of coal or raw materials for the by-product production. We have always counted on using Nitrate Plant No. 2, but we have not made any specific plans to use the Tennessee Valley Authority. We will have to wait until the end of this litigation. My contact with the Tennessee Valley Authority began in the last few weeks since this case began. The Tennessee Valley Authority, as soon as it gets the furnaces going, will, in a few years, be an important source of raw materials, but at the present time it is undeveloped.

Upon **Redirect Examination** the Witness Testified as Follows:

So far as we are concerned, we are not interested in the cost of preparing nitrates at Nitrate Plant No. 2. If it can produce it is extmerely valuable to us. The fact that another plant by another process can produce more

cheaply does not make any difference to us. The book entitled, "Industrial America in the World War," by Grosvenor D. Clarkson, is a standard text book and is regarded as authoritative. The report of the War Industries Board entitled, "American Industry in the War," is printed by the Government Printing Office and is authoritative.

At this point the excerpt beginning upon page 148 of the report of the War Industries Board, identified by the witness, was read. The substance was as follows: The aluminum industry of the United States is in the hands of one concern, the Aluminum Company of America. Power was the limiting factor in increasing the production of aluminum during the war. Not enough aluminum could be produced to supply the war needs of the United States and the Allies. The War Industries Board assisted the Aluminum Company of America in securing the necessary power for increased production.

The excerpt on page 169 of the same report was read, the substance of which is as follows: There was a great demand during the war for chlorine to be used in the manufacture of toxic gases, chemicals and smoke screens, "dope" for airplanes and textile bleaching power. There was a shortage of at least 20% in liquid chlorine.

The paragraph appearing on page 193 was read, the substance of which is as follows: Metallic magnesium was used during the war in tracer bullets, as an alloy in shells and castings, as a substitute for aluminum in gas masks and as a flux for nickel and Monel metal. The country's capacity was about 40,000 pounds per month. This was not sufficient to meet the demands of the United States and the Allies.

The paragraph on page 199 was read and the substance of it is as follows: A shortage occurred in the high grade

abrasives, particularly emery, corundum, and silicon carbide, used in grinding glass, steel and other metals. Many artificial abrasives were being manufactured at Niagara Falls. The congestion at that point, due to the large number of war industries depending upon hydro electric power, caused a shortage in abrasives, which in the summer of 1918 was threatening seriously to curtail many lines of war work.

Three passages from the book entitled, "Industrial America In the World War," were read, the substance of which is as follows: During the war the demand for aluminum for military purposes rose to 90% of the production and control of distribution became necessary. During 1918 the production of primary aluminum in the United States fell from the 100,000 tons of 1917 to 67,000 tons because of a shortage of water power during the winter. The Aluminum Company undertook to enlarge its capacity, but this was not accomplished before the end of the war. Electrodes for electric furnaces were so scarce, as were also abrasives that it took a section to look after them. The manufacture of large quantities of electro-chemical products created a large new demand for electrodes. There were 300 users of electrodes and only four producers. The up-shot of the shortage in abrasives was the discovery of an artificial abrasive manufactured at Niagara Falls. One of the complications was that in the competition for hydro-electric power, the abrasives industry was almost crowded out.

H. C. MINTON

Called as Witness on Behalf of Defendants Testified Upon **Direct Examination** as Follows:

I am a Major in the Ordnance Department of the United States Army. I am working under the Assistant Secretary

of War, devising a steel plan. By this we are attempting to provide the necessary steel for munitions manufacture in time of war. I have been in the Ordnance Department something over 15 years, and have been engaged in metallurgical work most of that time. Manganese is classified as a "strategic material." Copper, titanium and zinc are classified as "critical materials." Manganese is required in the manufacture of all steel. It is absolutely essential and no substitute has yet been perfected. The war time uses of copper follow closely its peace time use, with the added requirements of brass for cartridge cases, rotating belts for projectiles and various other uses. The war time demand will greatly exceed the civilian requirements. Titanium in peace time is used principally in the paint industry and in the manufacture of iron and steel, particularly the higher alloy steels. In addition to the usual peace time uses, zinc is necessary in war for containers for powder, for the linings of fixed rounds of ammunition and in the manufacture of abrasives. Ferro-alloys are alloys of iron so rich in some element other than carbon that they can be used as a means of reducing that element in steel. For instance, the commercial grade of ferro-manganese runs about 80% manganese, 6% carbon and most of the balance iron. The most important ferro-alloys are ferro-manganese, ferro-chromium, ferro-tungsten, ferro-molybdenum, and ferro-silicon. They are used in war time in the production of steel. Because of the high percentage of alloyed steels used by the army and navy in producing munitions, the demand would be considerably greater in time of war. The availability of a ready supply of electric power is an important factor in the production of these materials, particularly, with respect to the low carbon ferro-alloys. The development of a process for the utilization of domestic ores is highly important. A going

industry would be of immense value to the national defense in case of war. Manganese is considered to be the most important of the raw materials. Before the war we had very little in the way of a ferro-alloy industry. Most of our ores were imported. When we entered war we were faced with an immediate shortage of manganese and chromium, and we never did catch up with the demand. At the present time, there is a very minor production of the ferro-alloys in this country. Most of them are still imported.

I am familiar with "Special Text No. 229, Industrial Mobilization." The extracts appearing on pages 54 and 55 which are in substance as follows: The commercial supply of high grade manganese comes mainly from Russia, India, Brazil and the Gold Coast. The world consumption of manganese ores is about 3,000,000 tons a year. The United States is the greatest consumer of manganese ore and possesses only small deposits of high grade material. There are immense deposits of low grade material in this country, but to date no economical method for their utilization has been discovered. The deposits and the high cost methods of production required become of importance in a protracted emergency. The time required for the needed investigations and for the output of material in the quantity required to support our war time steel industry may be so great that if imports are stopped or curtailed, a serious shortage of high grade steel will result. The necessary quantities of manganese exist in this country, and American inventiveness and ingenuity would no doubt provide a method of making them available, but the time required may be fatal to an emergency program; express what I consider to be the true situation.

The conduct of research for the purpose of making avail-

able means by which domestic manganese can be produced in peace or war time is a helpful activity from the standpoint of the national defense. I am familiar with the report of the sub-committee on manganese of the Committee on Industrial Preparedness of the American Institute of Mining and Metallurgical Engineers entitled, "Manganese for National Defense." In my opinion that report is authoritative and impartial. I think that the statement that appears on page 34, which is as follows: "Nevertheless we feel that processes might be developed applicable to the large low-grade reserves which would be non-commercial in normal times, but which might be thoroughly demonstrated to be sound and therefore practical in times of stress such as in a war emergency. The investigation of such processes and their demonstration on an operating scale is obviously not an undertaking for private enterprise, but its importance to the national defense is unquestionable," is a thoroughly sound statement.

Assuming that the use of electric power is the accepted source of energy for the processing of chromium, nickel, tungsten and other ferro-alloys, I would say that the availibility of large amounts of electric power and of 12 electric furnaces in operating condition at Nitrate Plant No. 2 would be very valuable in the event of war. Manganese of ferro grade has been produced in electric furnaces from ores carrying 35% or more of manganese. I should say that the availability of large amounts of electric power, and these electric furnaces would be of decided value in the event of war. The further development of domestic industries in this part of the metallurgical field would be desirable from the standpoint of preparedness.

Upon **Cross-Examination** the Witness Testified as Follows:

I have never seen the particular furnaces at Nitrate Plant No. 2, and have formed no opinion as to their adaptability to the production of ferro-manganese. I know approximately where the larger deposits of manganese ore are found. The largest deposits of ferro grade ores are in Minnesota and Montana. There are huge deposits of the lower grade ores in Arkansas. I am not personally familiar with the deposits in Tennessee. I only know about that in a general way. The steel plan upon which I am working is under the planning branch of the office of the Assistant Secretary of War. I have known of the possibilities of the Tennessee Valley Authority since the Act was first passed. From various reports of the government bureaus, I would say that the Tennessee deposits of manganese ore are not of a grade that can be commercially marketed at this time. We are receiving the complete cooperation of the steel industry in our plans. The steel plan, of course, is distinct from a plan for the procurement of manganese, but so far as our plan is concerned, we are meeting with adequate cooperation from industry. The existing capacity for the production of steel is in excess of the existing market. At the present time the steel industry is operating at about 55% of capacity. It is true that the Bureau of Mines has been conducting studies as to all of these alloys and has been doing excellent work in that regard.

EDWIN C. ECKEL

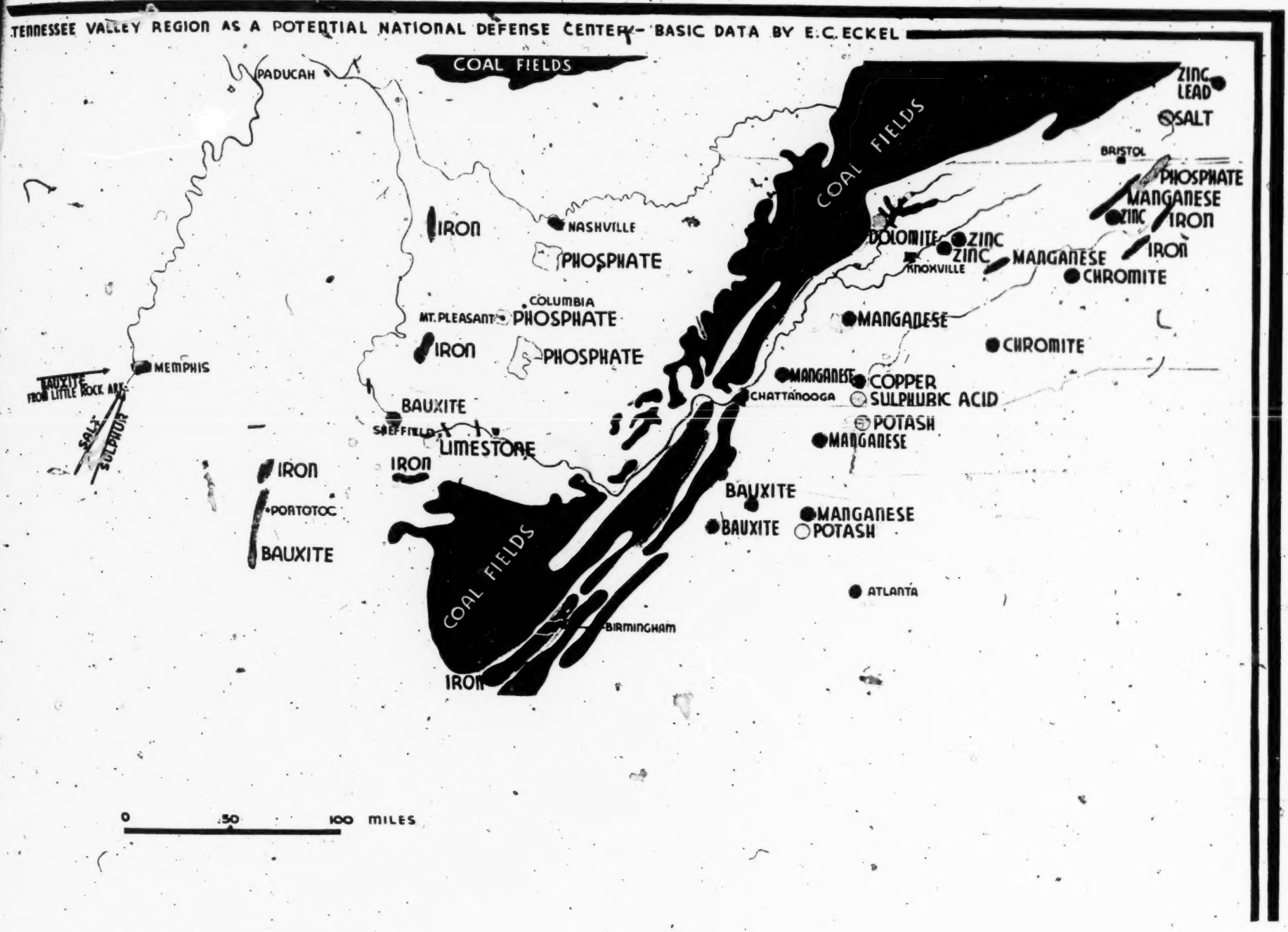
Called as a Witness on Behalf of the Defendants Testified upon **Direct Examination** as Follows:

I am Chief Geologist of the Tennessee Valley Authority, and have occupied that position since September of 1933.

My work covers the safety of the engineering structures, the examination of damage claims placed on the mineral values from reservoirs, and other damage claims against our structures in the reservoir areas. It covers the location and examination of supplies for engineering structures. In addition to that we have been carrying on investigations of minerals of the special type, development of which would employ electric power. I graduated from the Engineering School of New York University in 1896. I became Assistant State Geologist of New York State in 1898; Assistant Geologist of the United States Geological Survey in 1900; geologist in charge of valuations of iron manganese and aluminum ore in 1907. In that year I resigned and took up private work until the spring of 1917, when I went into the army.

In modern civilization, I should say that coal, iron ore, limestone, salt and some form of sulphuric acid are absolutely essential. The structure of civilization is built on those five materials. Steel, coal, iron ore and limestone are present in the Tennessee Valley. Salt is present in the Valley at its northern extreme. The chart entitled, "Tennessee Valley Region as a Potential National Defense Center," was prepared under my supervision and direction and represents the true situation. (At this point the chart above referred to by the witness was introduced in evidence as defense Exhibit #91, a copy of which is reproduced upon the opposite page.) The coal and iron ore are both present in enormous quantities. There is still plenty of limestone. Our best estimate for the phosphate regions of Tennessee is about 20,000,000 tons of recoverable phosphate. That includes both the low and the high grade ore. In the blue phosphate field, there is estimated to be about 100,000 tons of very low grade rock. We have a very

Defense Exhibit No. 91.

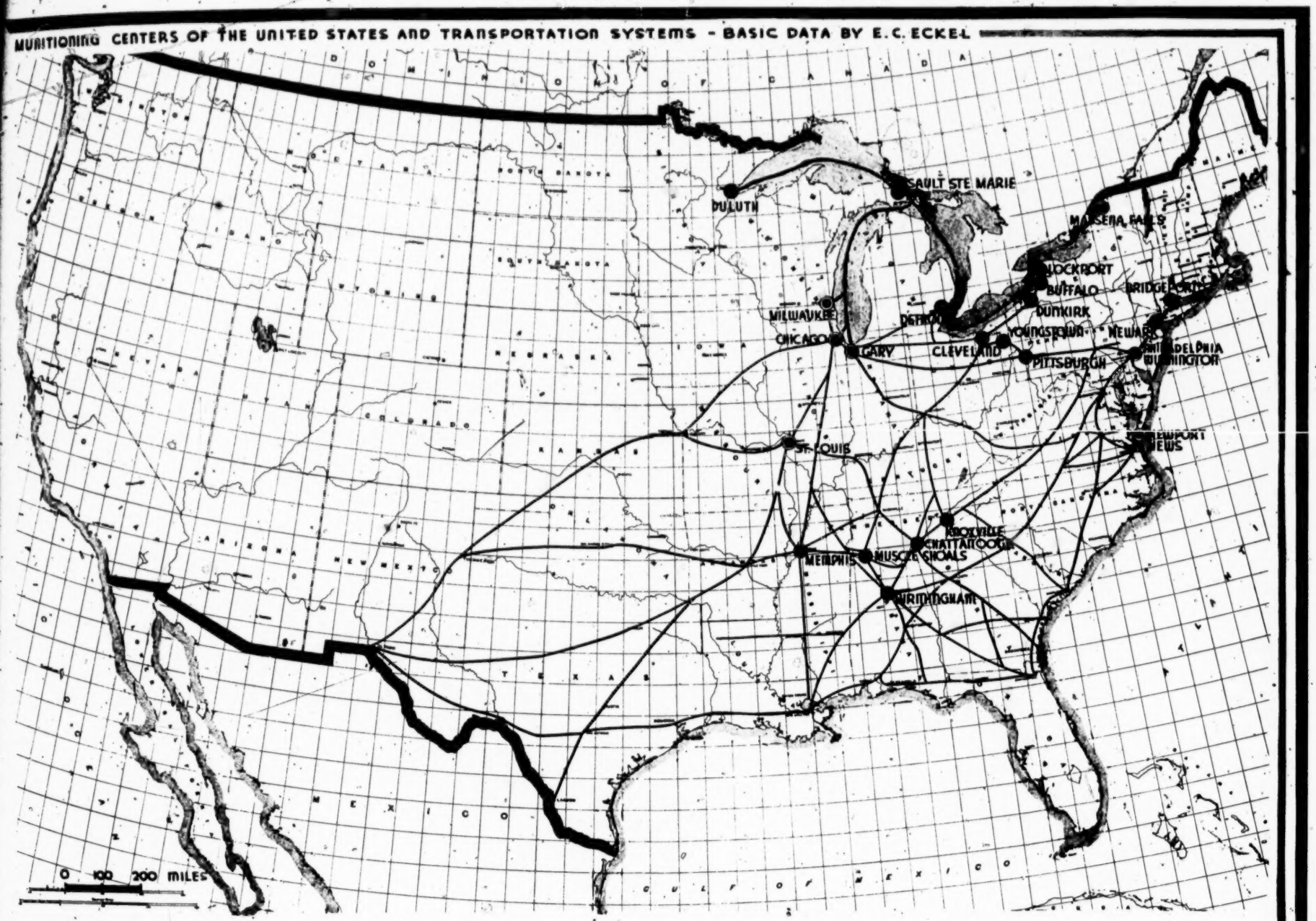


little chromite, a matter perhaps of a thousand tons and no more. There is a large zinc field in East Tennessee. There are extensive deposits of very low grade manganese ore which must be either concentrated mechanically or chemically treated. There are small high grade deposits in Georgia. The potash this is present is recoverable in war conditions, but not under peacetime conditions. Bauxite is present, possibly three or four million tons of low grade ore in Mississippi, and perhaps a quarter of a million tons of high grade ore in the rest of the region. Almost all of those mineral resurces are useful for purposes of national defense. There are a number of non-metals which are very important. We produce a large percentage of mica, feldspar and quartz, and we have an enormous output of clays of all sorts. Large quantities of electric power are required in the production of aluminum from bauxite, magnesium made from dolomite, the high grade ferro-manganese, ferro-silicon and ferro-chromium alloys, electrolytic zinc, electrolytic copper, electrolytic alkali and the phosphorus compounds about which Dr. Curtis spoke.

The Tennessee Valley is the only absolutely self-contained, protected munitions center in the United States. It is the only steel center that gets its raw materials at safe distances from frontiers. That is really all that needs to be said. It is not generally realized how badly located the other centers are. Practically every one of them is along the Canadian border or the Atlantic coast. The chart entitled, "Munitions Centers of the United States and Transportation Systems," was prepared under my supervision and direction. It does not purport to show all of the transportation systems outside of the Valley. It was designed simply to show the main rail routes from the Valley region. (At this point the chart above referred to

was introduced in evidence as defense Exhibit #92, a reproduction of which appears upon the opposite page.) On that map I put in the chief steel centers of the country and the aluminum production points. The Sault Ste. Marie Canal is the bottle neck of our national defense. Actually, it is very much more important to us than the Panama Canal today because it is entirely unprotected. It carries practically all of the iron ore that is used in the United States. It is half in Canadian territory and half in our own. We figured some years ago that it would be impossible to handle the iron ore by rail facilities if the Sault Canal was cut. If we assume that it may be cut, the entire burden is left upon this area here, which is protected by the mountains. An important point is that this region is accessible to other regions, and when it has a nine foot channel through to the Gulf, the transportation facilities will be excellent. If the nine foot channel is procured that would take the strain off the railroads of work for which they are not adapted. The railroads cannot handle iron ore and coal and cement and Great Lakes products in time of war when we need the cars shuffling back and forth as fast as possible. Furthermore, in the Tennessee Valley you have an adequate power supply and a good labor supply. The climatic conditions are favorable as you can operate the year around in the iron and coal mines, as against an annual tie-up in the Lake regions. The development of some of the mineral resources depends entirely upon electric power. The availability of that power would aid in building up small industries that could be transformed rapidly into munitions work in time of war. (At this point there was introduced in evidence as defense Exhibit #93 a certified copy of memoranda from Col. J. W. Joyes, Ordnance Department, United States Army, to the Chief of Ordnance, dated September 19, 1917, and from the Chief

Defense Exhibit No. 92.



of Ordnance to the Secretary of War, dated September 20, 1917, on the subject of "Sites for Nitrate Plants." The exhibit was offered not as evidence of the truth of the facts recited, but for the purpose of showing that the recommendation was made. It is omitted from this narrative.)

Upon **Cross Examination** the Witness Testified as Follows:

I do not know anything about any plan to move the munitions center of the United States to the Tennessee Valley. I stated that it would be a good place for a munitions center. I think the commercial development of some of these minerals is entirely practicable. We have put some of the Mississippi bauxite through the process and come out with materials that make it seem economical for private operation. I think the magnesium is feasible under certain conditions. I have come pretty close to suggesting during the last year that there is a possibility of commercial development of the manganese industry in this area. I think it is feasible if it is done on a cautious scale. The blast furnace process of producing ferro-manganese is entirely feasible. It is being produced in this district by that process. There is over capacity of everything in this country now except gold.

DR. DUNCAN MacRAE,

called as witness on behalf of defendants testified upon **Direct Examination** as follows:

I am Assistant Technical Director and Chief Chemist of the Chemical Warfare Service of the United States Army. I graduated from the University of North Carolina in 1909 with the degree of Bachelor of Science in Chem-

ical Engineering and received my Ph.D degree in Chemistry at the Massachusetts Institute of Technology in 1917. I have been Assistant Technological Director at the Edgewood Arsenal for the past five and a half years. Edgewood Arsenal is the manufacturing arsenal of the Chemical Warfare Service. The most important materials for chemical warfare which require electric power in some stage of their manufacture are acetylene, tetra-chloride, aluminum chloride, bleaching powder, chlorine, chlorosulphuric acid, chlorinated paraffin, carbon tetra-chloride, diphenylamine, sulphur trioxide, sulphur monochloride, and white phosphorus. The principal value of white phosphorus for chemical warfare is its high obscuring power. It also burns readily, causing painful and lasting wounds.

Upon **Cross Examination** the Witness Testified as Follows:

My duties are wholly technical and do not include procurement of supplies. I do not know anything about any negotiations between the War Department and the Tennessee Valley Authority for the production of these particular chemicals. There are very few chemicals in general industrial use that are not important factors in the conduct of a war. Sulphuric acid has manifold purposes in support of the army in the field.

WILLIAM E. MOORE,

called as witness on behalf of defendants testified upon **Direct Examination** as follows:

I am a consulting engineer specializing on electric furnaces. I have been engaged in that special work since 1916. I have been in the electrical and mechanical engineering field for years before that, particularly, in power produc-

Product	Process	Kilowatt hours required per short ton.	Kilowatt hours consumed in U. S. During 1929 in 1,000's	Principal competing processes in U. S. or other countries.
Aluminum	Electrolytic reduction of alumina to aluminum	19,000—25,000	2,519,375	None.
	Electrothermal reduction of bauxite to alumina	4,082	None	Alkali reduction of bauxite to alumina.
Ferro-alloys:				
Ferro-silicon 50-per cent	Electrothermal smelting	5,000	994,011	By product of fused alumina production. Blast furnace reduction for less than 12 per cent silicon.
Ferro-molybdenum,	do	8,000— 9,000)		
Ferro-uranium	do	6,000—10,000)	228,258	None
Ferro-chronium 60 per cent	do	6,000)		
Ferro-tungsten	Electrothermal smelting & refining	7,600	26,396	Do.
Ferro-vanadium 30 to 35 per cent	Electrothermal Smelting	7,800	13,035	Thermit reduction.
Ferro-manganese 80 per cent	Electrothermal reduction	4,400	None	Blast furnace reduction.
Calcium carbide	Do	2,600— 3,200	720,000	None.
Caustic soda and chlorine	Electrolytic reduction of brine	2,328— 2,984 (per ton of caustic soda)	660,000	Lime-soda ash process
Copper	Precipitation from oxide & mixed ores	1,700— 2,625	62,849	Flotation & reverberatory smelting.
	Electrolytic refining	141— 233	309,351	None
	Electric furnace smelting for alloying.	200— 300	220,000	Fuel fired pit furnaces.
	Annealing	50— 100	.....	Fuel fired furnaces
Zinc	Electrolytic precipitation	2,206— 3,200	507,115	Retort distillation
Steel:				
Castings	Electric Smelting solid charge	500— 760	281,594	Open hearth furnace. Bessemer furnace. Crucible furnace.
Ingots	Electric melting or refining or super-refining of molten charge	210	125,219	Open hearth furnace. Bessemer furnace. Crucible furnace.
Treatment	Electric annealing or hardening	182— 286	.....	Fuel fired furnaces
	Electric galvanizing or electro-zincing	101— 230	.....	Fuel, hot process.
Crystalline graphite	Electrothermal reduction	7,600	91,200	None
Phosphoric acid	Do.	5,400	81,000	Sulphuric acid process. Blast furnace reduction.
Oxygen (Compressed)	Electrolytic reduction of water	250)		(Liquefaction process
Hydrogen	do	140)	50,575	(Water, gas and iron contact processes
Fused alumina	Electrothermal fusion	2,000— 2,540	43,318	None
Carbon bisulphide	do	850	30,179	Do
Silicon carbide	Electrothermal reduction	6,666— 8,333	23,655	
Potassium hydroxide	Electrolysis of potassium chloride	2,000— 2,300	15,831	Chemical process
Synthetic ammonia	Electrolytic hydrogen; pressure synthesis	12,055	13,140	Water gas hydrogen; coke oven gas hydrogen; by-product hydrogen.
Metallic magnesium	Electrolysis of magnesium chloride in brine	16,000	10,640	Electrolysis of magnesium chloride from mineral magnesite plus chlorine requiring 17,000 KWH
Lead	Electrolytic refining	95— 111	6,180	
Cadmium	Electrolytic precipitation of zinc residue	2,000— 2,500	2,730	None
Silver	Electrolytic refining	316— 714	1,283	Sulphuric acid process.
Phosphorus	Electrothermal reduction	9,000	1,250	None
Gold	Electrolytic refining	266	45	Sulphuric acid process.
Metallic sodium	Electrolysis of fused caustic soda	13,000	(7)	Electrolysis of fused sodium chloride.

[illegible]	[illegible]	[illegible]	[illegible]	Flotation & reverberatory smelting.
	Electrolytic refining	141— 233	309,351	None
	Electric furnace smelting for alloying.	200— 300	220,000	Fuel fired pit furnaces.
	Annealing	50— 100	.....	Fuel fired furnaces
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Hydrogen	do	140)	50,575	(Water, gas and iron contact processes
Fused alumina	Electrothermal fusion	2,000— 2,540	43,318	None
Carbon bisulphide	do	850	30,179	Do
Silicon carbide	Electrothermal reduction	6,666— 8,333	23,655	
Potassium hydroxide	Electrolysis of potassium chloride	2,000— 2,300	15,831	Chemical process
Synthetic ammonia	Electrolytic hydrogen; pressure synthesis	12,055	13,140	Water gas hydrogen; coke oven gas hydrogen; by-product hydrogen.
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Cadmium	Electrolytic precipitation of zinc residue	2,000— 2,500	2,730	None
Silver	Electrolytic refining	316— 714	1,283	Sulphuric acid process.
Phosphorus	Electrothermal reduction	9,000	1,250	None
Gold	Electrolytic refining	266	45	Sulphuric acid process.
Metallic sodium	Electrolysis of fused caustic soda	13,000	(7)	Electrolysis of fused sodium chloride.
Fused quartz	Electrothermal fusion	10,000—16,000	(8)	None
Silicon	Electrothermal reduction	12,000	(8)	Do
Potassium chlorate	Electrolysis of potassium chloride	1,350	(8)	Chemical process.
Iron	Magnetite ore reduction in arc furnace	2,000— 2,500	None	Blast furnace. Electro-deposition.
	Electro-deposition from ore	900	None	Blast furnace. Electric furnace reduction.
Sponge iron	Electrothermal low temperature ore reduction	400	(8)	Oil or gas low temperature reduction.
Iron castings	Electric melting Duplex systems, continuous	115— 550	(8)	Fuel fired cupola melting
Nitric acid	Arc	61,000	None	Oxidation of ammonia.
Calcium cyanamide	Electrothermal reduction	2,830	None (9)	None

Foot Notes:

(2) 1927 figures.

(3) Includes power required in operations immediately essential to electrolytic precipitation of zinc.

(4) Kilowatt-hour per 1,000 cubic feet.

(5) Canadian and United States consumption in 1929 was 152,489,000 kilowatt-hours for production of fused alumina.

(6) Canadian and United States consumption in 1929 was 227,000,000 kilowatt-hours for production of silicon carbide.

(7) United States production not officially recorded. Estimated world consumption in 1927 was 375,000,000 kilowatt-hours for manufacture of metallic sodium.

(8) Not reported.

(9) The amount of calcium cyanamide shipped into the United States required 84,900,000 kilowatt-hours to produce.

tion and installation. The two industrial processes which require the utilization of large quantities of electric power are electric furnace plants and electrolytic plants. In the latter process instead of a furnace a cell is used and direct current is employed. In the electric furnace, alternating current is generally used. That is known as the electro-thermal process. Some of the principal war materials which are produced by the electrolytic process and which require sizeable amounts of electric energy are aluminum, magnesium, copper, zinc, chlorine, the alkaline minerals and some of the caustics. Some of the principal war materials which are produced by the electro-thermal process are the ferro-alloys, the hydrate-alloys, steels, phosphorus, phosphoric acid, acetylene materials such as carbide, refractories, silicon carbide and aluminum. Considerable amounts of electric power are required in the production of all of those materials. I have examined the table entitled, "Electrical Requirements of Electrochemical Processes in the United States During 1929," appearing on pages 43 and 44 of House Document 103, 73rd Congress, 1st Session. That table is correct. (It being impracticable in the opinion of the Court to reduce the table referred to to narrative form, the same is reproduced in words and figures upon the opposite page).

At the time that the Tennessee Valley Authority began to revamp Nitrate Plant No. 2 for the manufacture of phosphoric acid, I was called in and designed the furnace; the first one put in for the manufacture of phosphoric acid. There are 12 electric furnaces at Nitrate Plant No. 2 of 8,300 KW capacity each, those furnaces can be used for the manufacture of carbide and the ferro-alloys. With slight changes they can be used for the production of phosphorus. With changes in the furnace principles that

plant can be adapted to manufacture steel of various grades, the more expensive ferro-alloys, abrasives, refractories and graphite. The products which I have described would not require any change from alternating to direct current. If the plant is prepared for direct current operation, it would be possible to produce aluminum, magnesium, the various alkalis, oxygen, hydrogen, chlorine, sodium, zinc, and copper. All of those materials are required in large quantities in the event of war. In my opinion, in the event of a war, the 12 electric furnaces at Nitrate Plant No. 2, with the available power supply would be a valuable asset to the national defense. A number of these materials can not be produced in any other way except by electrical furnace or electrolytic processes. Furthermore, the electric furnace is very quickly constructed and operated comparatively cheaply, providing suitable power supply is available. The availability of power is a limiting factor in the use of the electric furnace and the electrolytic process to meet increased war requirements. There was an actual shortage of power that was felt in some of the most important industrial and munitions centers during the last war.

Upon **Cross Examination** the witness testified as follows:

The two processes to which I have referred are within the range of existing industrial practice and experience. All of those materials mentioned have been produced by the electric furnace or the electrolytic process. The only particular design that I have made has been for the phosphate furnace. Two of the carbide furnaces have been converted to produce phosphoric acid. The 10 remaining carbide furnaces are standard carbide, ferro-alloy furnaces and are ready to produce those products. Some changes

were required for producing phosphoric acid. It was necessary to tear down parts of the furnaces, but the more expensive parts are still there; that is, the electrical equipment. They are three phase furnaces. All of the materials that I have listed, as being produced by this type of furnace, can be produced by a three phase furnace. Trioxide could be produced there. Most of the materials that I have mentioned were manufactured for use in the last year. All of them are industrial materials and processes. The existing 10 furnaces could be converted for ferro-alloys, such as I have listed, within a few weeks. The furnaces as they stand with very slight changes are adaptable to the production of ferro-alloys and they are made for calcium carbide. They would also produce the refractories and abrasives. New electric steel melting furnaces could be constructed in 90 days, or perhaps even less under pressure. The furnace producing capacity for ferro-alloys is not fully occupied at present, but with the return of normal production in the steel industry, it would be fully occupied. In the copper industry, the production of copper is primarily a blast furnace process, but refining by the electrolytic process is required in practically all cases. Oxygen is produced by liquefication of the air, but that grade is not as pure as the grade produced by the electrolytic process and is more extravagant. Hydrogen can be produced through the coke process. If the government should go into the manufacture of these metals on a large scale I should say that that would have a competitive effect upon the industrial market.

Upon **Redirect Examination** the witness testified as follows:

Calcium carbide is the base of acetylene gas. That can

not be produced by any other means than the electric furnace. The furnaces as Muscle Shoals would be useful for that purpose. The higher alloy grade of ferro-silicon is commercially produced only in electric furnaces. Ferro-chromium is commercially produced only in electric furnaces. There is a high requirement in KW hours for that production; roughly, 6,000 KWH per net ton. The electric furnace is used exclusively for the commercial production of artificial abrasives. The electrolytic process is cheaper than any other in the production of caustic soda and chlorine, and it is practically the only way to produce them at commercial cost. The production of graphite from carbon is entirely by means of the electric furnace. The use of electricity in the production of these products is increasing.

DR. HARRY A. CURTIS,

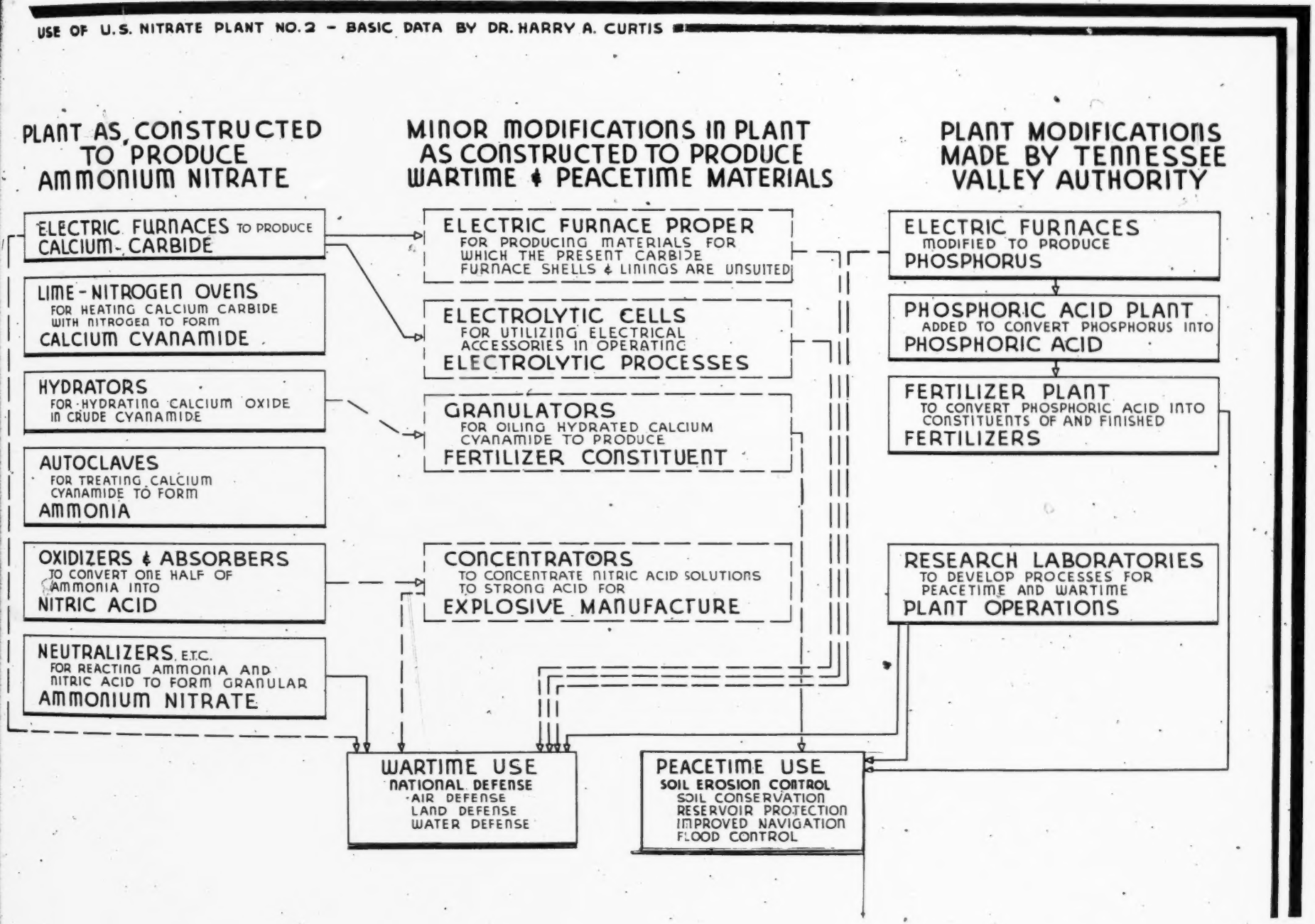
recalled on behalf of the defendants, testified upon **Direct Examination** as follows:

When I was with the Nitrate Division of the Ordnance Department, I was assigned to go to Muscle Shoals to set up a chemical engineering experimental laboratory. I visited a number of plants and laboratories where work of interest to the Nitrate Division was being carried on. Since the war, I have kept in general touch with the production of war materials, especially with respect to fixed nitrogen. At the beginning of the World War, there was a great problem as to where we were going to obtain the amount of fixed nitrogen necessary. The first thing that was done was to start the design and construction of United States Nitrate Plant No. 1, under the provision of the National Defense Act. It was realized that the synthetic ammonia process which was to be used in

Nitrate Plant No. 1 was not very well known outside of Germany. There were two other processes that had been operated commercially. One was the arc process which requires such tremendous amounts of power it can be used only where power is very cheap, and where there are no other large uses for it. It was finally decided to place our reliance on the cyanamide process. We knew how to operate that, and it appeared as though we might be able to get sufficient power for it. Power was one of the great considerations through the war. A contract was finally made with the Air-Nitrates Corporation to build Nitrate Plant No. 2 for the government. It became evident that Nitrate Plant No. 2 could not supply the amounts that would be required. Plans were discussed for the location of other plants. The matter of obtaining the necessary power was acute, and the discussion finally came down to where we could get the power. Power was finally found in Ohio at two sites, and the proposed plant was divided into two parts, known at Nitrate Plants No. 3 and No. 4. These plants were partially constructed at the end of the war. In 1918, the War Industries Board reached the conclusion that there still would not be enough nitrogen, and recommended the construction of plants that would be equal to the capacity of everything that had been projected up to that date. In the problem of locating Nitrate Plant No. 1, studies had been made by two or three different commissions, appointed by the President and the War Department. The whole problem of location from the standpoint of production, climate, available power, and other factors had been considered. When the problem of locating Nitrate Plant No. 2 came along, it was indicated that Muscle Shoals, where power could be obtained, was the obvious site. In order to obtain the necessary power a con-

tract was made with the Alabama Power Company to build an extension to the Gorgas Steam Plant, of that Company, and the transmission line between that plant and Nitrate Plant No. 2 was installed. Construction of a steam plant was undertaken, and plans were laid for the construction of the Wilson Dam. The operation of Nitrate Plant No. 2 for the production of ammonium nitrate at the capacity for which the plant was designed would require between 700,000,000 and 800,000,000 KWH per year; or in terms of KW, 80,000 to 90,000 KW. The chart entitled, "Use of United States Nitrate Plant No. 2," was prepared under my supervision and direction. (At this point the chart above referred to by the witness was introduced in evidence as defense Exhibit No. 94, a reproduction of which appears on the opposite page). Briefly the process is that limestone is brought to the plants and burned to lime in kilns. Coke is mixed with the lime and then brought together in electric furnaces, where by means of the heat the two form calcium carbide. The calcium carbide is crushed and ground and placed into a larger number of small lime nitrogen ovens. These are heated electrically and nitrogen obtained from the atmosphere is passed through the ovens. The contact of the nitrogen with the hot carbide in the ovens results in a chemical reaction whereby the nitrogen becomes fixed in the form of calcium cyanamide. The calcium cyanamide is removed from the lime nitrogen ovens, is crushed and ground and treated with a supply of water in an apparatus known as a hydrator. The hydrated cyanamide is then placed in auto claves and treated with caustic soda and steam and the chemical reaction takes place wherein ammonia has reappeared as a gas. The ammonia is divided into two parts: one part is sent to oxidizers where it is oxidized to a nitric oxide,

Defense Exhibit No. 94.



and eventually converted to nitric acid. That nitric acid is then combined with the other half of the ammonia to form a solution of ammonium nitrate. This solution is evaporated and graulated to form the ammonium nitrate which is the final product.

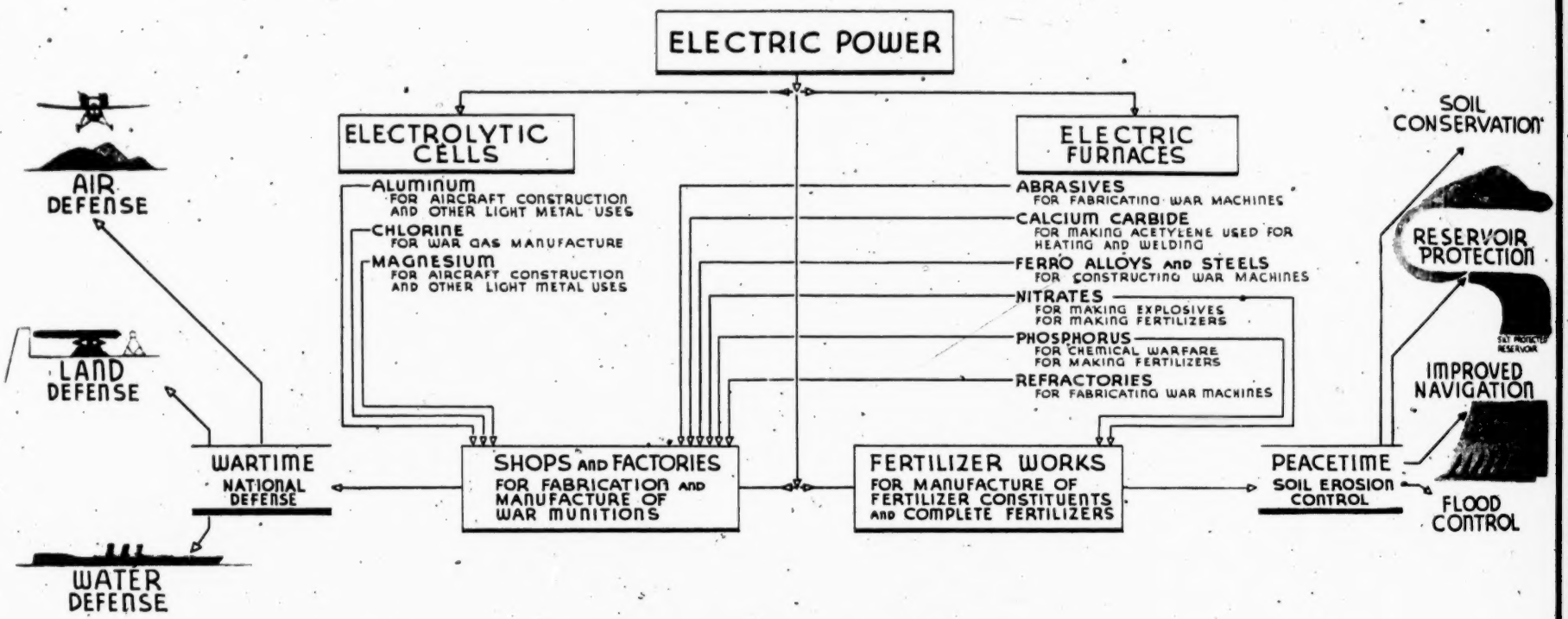
Nitrate Plant No. 2 is obsolete in about the same sense than an automobile purchased in 1930 and not used would be. No one would consider, perhaps, buying such an automobile today, but if the automobile had been kept well greased and polished and painted, I don't think that anyone would have any doubt about using it in an emergency to get somewhere. That is about the same situation with reference to Nitrate Plant No. 2. It is the newest cyanamide plant in the world. It is true that great developments have been made in the synthetic ammonia process, and there have been no new cyanamide plants built. There is no question that Nitrate Plant No. 2 could be operated and could produce the amount of ammonium nitrate for which it was originally designed. If ammonia could be brought in from an outside source, it would be unnecessary to operate the nitrogen fixing part of the plant, and there is today an enormous capacity for producing synthetic ammonia. Ammonia is shipped in tank cars and in the event of war it would be a question of shipping from Belle, West Virginia or Hopewell, Virginia to Muscle Shoals in order to make ammonium nitrate. If it were feasible it would probably be the thing to do. If not, you could operate the plant and produce the ammonia there. If ammonia could be brought in from some outside source, it could be substituted for the ammonia, which the plant produces, the rest of the process being identical. The capacity for producing nitric acid and ammonium nitrate in the United States has not kept pace

with the capacity for the production of ammonia. It is my opinion that Nitrate Plant No. 2 has a substantial value as a national defense asset, because it can be used either to manufacture ammonium nitrate by the cyanamide process, if that becomes necessary, or a portion of the plant can be utilized for the oxidation of ammonia and the production of ammonium nitrate in that way.

It would be possible to produce the white phosphorus which is required for military purposes at Nitrate Plant No. 2. In the electric furnaces as they have been modified to produce phosphatic fertilizers, lime and slag and coke are smelted together and as a result of the heat elementary phosphorus is evolved from the furnace in the form of a gas. In the plant as constructed that phosphorus is burned. It would be a very simple matter to install condensers whereby this elementary phosphorus could be condensed into the ordinary white phosphorus that is used for military purposes. That equipment is very simple, and we could install the first condensers in the course of a week or so. From an engineering standpoint that is a very simple problem. It is what we actually contemplate in the event of emergency. We are actually designing condensers to condense phosphorus from these furnaces. The two furnaces with condensers attached would produce about 20,000 tons of elementary phosphorus per day. In my opinion, the substitution of phosphorus furnaces in place of the carbide furnaces, up to a certain point, is an enhancement of the value of the plant from a national defense standpoint. By this means we have made available a new war material. We have established a going chemical control laboratory, and have built up a personnel which is becoming increasingly skilled in operations of this sort. A trained personnel in chemical operations is one of the very valuable assets of a nation in time of war.

Defense Exhibit No. 95.

USE OF ELECTRIC POWER - BASIC DATA BY DR. HARRY A. CURTIS



NOTE: This chart illustrates actual and potential uses of electric power at Nitrate Plant No. 2 for national defense. The twelve electric furnaces now located there may be used to manufacture any of the War materials listed. Some changes would be necessary in the equipment. The various materials specifically mentioned are important War materials. Electric power to the furnaces and cells could be used to manufacture these materials and others which are not mentioned specifically. Shortages in many of these materials occurred during the World War, and shortages in future wars may be expected. The raw materials for a number of the products mentioned are available in the Tennessee Valley.

Judging by the last war there would be a tremendous demand for power in the event of another one of similar magnitude. One difficulty is that power is used in such ways that it cannot be readily withdrawn for military use. In so far as power is being used in the production of fertilizer for soil conservation and related problems that power would be available in an emergency, because you could allow soil erosion to take place for a short time and divert that power to more urgent needs without seriously up-setting the life of the people. Since the electric furnaces for the production of carbide are available they can be used for that purpose as originally intended. There is a residual value in these furnaces for that purpose. By making certain modifications the furnaces can be used for the production of certain ferro-alloys and for graphite. The chart entitled, "Use of Electric Power, Basic Data by Dr. Harry A. Curtis," was prepared under my supervision. (At this point the chart above referred to by the witness was introduced in evidence as defense Exhibit No. 95, a reproduction of which appears upon the opposite page). Large quantities of electric power would be necessary to produce the war materials that have been mentioned in these furnaces. This defense Exhibit No. 95 shows from a chemical standpoint the general relation of the peace time and war time uses of electric power, in the electrolytic cells on the one hand and in the electric furnaces on the other. In the electrolytic cells there would be produced aluminum for aircraft construction and other light metals; chlorine for war gas and magnesium for the same purposes as aluminum. Those materials, in general, would go into shops along with the power in order to manufacture munitions of war. In the electric furnace there would be produced such materials as abrasives, calcium carbide, ferro-

alloys, nitrates, phosphates and refractories. The nitrates and phosphates can be used as fertilizers in peace time for the purposes of eliminating soil erosion, which is required in the prevention of silting and the protection of reservoirs for the improvement of navigation and the control of floods. There were war time shortages in all of the materials that I have listed. The production of each of those materials is a power consuming process. In our experimental work we are endeavoring to devise ways of making use of the low grade manganese ores and low grade bauxites.

Upon **Cross Examination** the Witness testified as Follows:

I have pointed out from the beginning of this work that the proposed use of the nitrate plant for the peace time manufacture of fertilizer was in no way inconsistent with the national defense objective. Obviously, there are certain industries more closely related to the national defense than others. In time of war, power is rationed, war needs taking precedence over everything else. It is generally true that the nation with the best developed industries is the best prepared in event of war. It is true that anything that would interfere with the flexibility of the control of power would to that extent militate against its use for national defense. As I have stated, I believe power is a great national asset in the national defense. The commitment of that power affects that asset insofar as its value is concerned. The most valuable is that which can be readily diverted to direct war time use. The plan of using fertilizer in connection with erosion and to improve navigation was discussed with me when I first came with the Tennessee Valley Authority. It was my business to

find the ways and means of using these plants, but the general plan of conserving the soil and preventing erosion is a religion with Dr. H. A. Morgan. In this soil erosion control program phosphorus is of more importance than nitrates. The amount of erosion varies enormously in different watersheds. There are watersheds where the problem is negligible while there are others, such as this region, where all of the various factors that have been described in the testimony combine to make the problem one of the worst in the country, so far as the protection of the dams is concerned. I have not indicated any method by which the United States should engage in the distribution of fertilizer. I have nothing to do with the operation of any utility network. All I want is to be given the electric power to carry out my program and I have been promised the necessary amount. Referring to the defense Exhibit No. 8, which is a photograph of the nitrate plant, the electric furnaces are housed in this long building, appearing in the left center of the picture. The oxidation is carried out in this building, appearing in about the center of the picture, the low line of buildings in the background. That process is functionally separate from the electric furnace, and can be carried out anywhere where these facilities are available. By far the greater part of the energy requirement is used in the electric furnaces. I would say that that part of the plant which involves the oxidation of the ammonia could be constructed in about six or eight months. The Hopewell plant has a large capacity for converting ammonia into nitric acid. The Belle, West Virginia plant produces ammonia and alcohol. I do not believe that they produce nitric acid. It has an enormous capacity for the production of ammonium. Since the war the synthetic nitrogen processes

have replaced the high power consuming processes, such as the arc process, but the cyanamide plants are still in operation, and are seemingly able to compete. No new plants have been built with the cyanamide process. In my opinion if anyone were desirous of producing ammonia as a base for nitric acid or for fertilizer, some other process than the cyanamide process would be used. I would say that no manufacturing concern wants a competitor if they can avoid it. The process in use at Muscle Shoals requires three or four times as much power per unit as the synthetic process would require. The blast furnace is the only process other than the electric furnace in use in the production of phosphoric acid. In the blast furnace there is very little power used compared with the electric furnace. In the manufacture of super-phosphates, by the sulphuric process, there is very little electric energy used. That process does not produce phosphorus at any point, but it does produce phosphatic fertilizer. I was a member of the Muscle Shoals Inquiry appointed on March 26, 1925, by President Coolidge. In general, I am still of the same opinion that I was at the time I made the minority report of that Commission. At that time the proposal was to operate those nitrate plants to produce certain specified quantities of nitrogenous fertilizer. I still consider that plan uneconomical. There was no agency set up such as the Tennessee Valley Authority to use part of that fertilizer in a soil erosion prevention program. My minority recommendation contained in Item II, was as follows:

> "That all the power at the Wilson Dam, with the steam plant in Nitrate Plant No. 2 used as an auxiliary, be reserved for a period of two years from the time the necessary legislation becomes effective, and that

75,000 primary horse power, together with 30,000 secondary horse power be reserved for an additional year, all for the purpose of manufacturing fertilizer or utilizing the equipment of Nitrate Plant No. 1 and No. 2. Those receiving the power to have the right to use it continuously, but not to resell any of it. All reserved power to be delivered to such customers and in such amounts as may be specified by the Muscle Shoals Board,"

and in connection with the lease the following was contained in that recommendation:

"That authority be given by Congress to some agent of the United States to lease Wilson Dam and appurtenances, the hydro electric power generating stations thereat and the steam electric power generating plant at Nitrate Plant No. 2, all for a period not to exceed 50 years."

Under the conditions enumerated in the report that was my recommendation. Those conditions were as follows:

"(a) To maintain and operate the power plants, using the steam electric plant as an auxiliary to the hydro electric;

"(b) To pay to the United States an annual rental for the power rights and properties a sum equal to 4% of the fair, present value of the properties estimated to be $42,000,000;

"(c) To deliver the power generated at Muscle Shoals as directed by the Muscle Shoals Board, provided, however, that any power not taken under the assignments of the Board may be sold by the lessee as hereinafter provided."

In the selection of that commission there was no requirement or suggestion that the members should be representa-

tives of any particular group or interest. My participation in it was with the sole view of representing my conception of the interest of the United States Government and its people. At that time and under the conditions that then existed, I joined with Mr. McClelland, who is now President of the Potomac Electric Light and Power Company in making the best recommendation we could think of in the minority report.

Upon **Redirect Examination** the Witness Testified as Follows:

I would like to point out that at the time of the minority report referred to, there had been considerable talk of the government operating the nitrate plant, as it stood, for the production of enormous quantities of fertilizer under the delusion that if that were done, fertilizer could be sold at half price. I was aware that an operation of that plant as it stood would result only in a great loss of revenue. I didn't believe then, and I don't believe now, that the government can go into the production of fertilizer, on an out and out proposition of selling it in the markets, effectively in competition with private interest. In that report, we attempted to safeguard the interests of the United States both with reference to fertilizer and with reference to power. So far as I know, no offer was ever made that conformed to the conditions prescribed. Under the present method of operation the main purposes set out in that report are being accomplished to a certain degree, material utilization of the plant for the national good and at the same time tieing that use in with the national defense. The availability under government control of an abundant supply of power at Muscle Shoals would be of practical aid in the national defense. The actual operation of

properties is a good method of keeping them in operating condition. In that minority report, we were considering only the nitrate plants and the Tennessee River, not the general problem of navigation on the Tennessee and flood control on the Tennessee and Mississippi Rivers.

The only officers with whom I have talked both before and after joining the Authority have been concerned with the problem of protecting munitions centers against attack in the event of war. There are other considerations, such as climate and availability of labor. I have discussed the matter with various army officers, and the general agreement is that a location inland is one of the considerations in the national defense. Newark, New Jersey, is usually referred to as the chemical center of the United States. There are important centers at Buffalo, Detroit, Chicago, Gary, Cleveland, and Pittsburgh. A munitions and chemical industry concentrated on the coast and along unfortified boundaries is most vulnerable to attack.

W. F. McFARLAND,

called as a witness on behalf of the defendant city of Florence, testified upon **Direct Examination** as follows:

I have lived in Florence, Alabama, all my life. I am familiar with the general situation and the history of that community. The corporate limits of the Town of Florence join the government reservation upon which the north end of Wilson Dam rests. The corporate limits of the Town of Sheffield join the western limits of the government reservation on the south side of the river. Tuscumbia is between four and five miles from Wilson Dam. Decatur is 25 or 30 miles from Wilson Dam. Wilson Dam was completed in 1925 or 1926. Some part of the surplus power produced at that dam has been sold by the United States

Government to the Alabama Power Company ever since the dam was completed, and the Alabama Power Company has transmission lines to the power house at the dam. During the last few years there has been a physical connection between the generating plant at the dam and the Tennessee Power Company. I do not know whether they get the electricity direct from the government or by purchase from the Alabama Power Company. The shoals in in the vicinity, prior to the construction of Wilson Dam, prevented navigation over that part of the river. Ever since I can remember the United States Government, and those communities up there, have been interested in removing that obstruction to navigation. In the past 25 or 30 years there has been an active organization in the Tennessee Valley known as "The Tennessee Valley Improvement Association," which has been primarily interested in the subject of flood control and navigation. In recent years the people in our section have been very much interested in securing power from the Tennessee River. Those communities have been deeply interested in Congressional legislation on the subject of navigation, flood control and power distribution, and have at different times sent representatives to hearings on legislation in Washington. They have always insisted that any legislation on the subject of the improvement of the river should carry with it the right of the municipalities to buy power from the government. Those communities were also actively interested in the enactment of the law that is now known as the Carmichael Act, enabling those towns to borrow funds and engage in the power business. The electric power systems in the three Muscle Shoals towns were constructed by the Parsons family in the name of the Sheffield Company, and the property and franchises of

that company were acquired by the Alabama Power Company six or eight or ten years ago. All of those franchises have now expired. Those towns have been interested for a long period of time in making provision for owning and operating their own electric distribution systems.

Upon **Cross Examination** the witness testified as follows:

I was a member of the Muscle Shoals Commission designated by the Governor of Alabama. That Commission was composed of members three of whom were designated by each of the States of Alabama, and Tennessee, and three by the President, Mr. Hoover. The personnel was as follows: S. F. Hobbs, Chairman, Selma, Alabama; William Howard Smith of Florence, myself; from Tennessee, R. L. Moore of Jellico, J. F. Porter of Columbia and Mercer Reynolds of Chattanooga. The three designated by the President of the United States were Edward A. O'Neill, President of the American Farm Bureau Federation; Colonel H. C. Ferguson, Corps of Engineers, United States Army, Lieutenant-Colonel Joseph I. McMullin, office of the Judge Advocate General, United States Army. Max C. Tyler, Corps of Engineers, United States Army was the technical adviser and Major George P. Hill, office of the Judge Advocate General was legal adviser. Captain Thomas H. Green of the office of Judge Advocate General was Secretary to the Commission. I joined in the unanimous report on behalf of that Commission.

The Alabama Power Company is serving the public in Florence, Sheffield and Tuscumbia as a public utility. They own property there and I assume that they are paying taxes. It is the only utility furnishing electric service in those towns at the present time. That service is being furnished under rates established by the Public Service

Commission. I do not know of any proceedings pending for the reduction of those rates, or any proceedings complaining of inadequacy of service. Rates have been reduced many times in the past. The Alabama Power Company is also serving the area surrounding the three cities, and it is the only utility that I know of in that end of the state. The Tennessee Valley Authority is operating service in Lauderdale County and Colbert County.

GENERAL AMOS F. FRIES

Called as Witness on Behalf of Defendants Testified as Follows upon **Direct Examination:**

I am a Major General of the United States Army, retired, and I was Chief of the Chemical Warfare Service during the World War. Chlorine gas is obtained by passing a very heavy current of electricity through salt brine. Wars are always fought with things developed in peace. Chlorine was a very important article of commerce, developed before the World War. It was shipped in great quantities throughout the world. Chlorine alone was used in the first attack and it was extraordinarily effective because nobody was prepared against it. It is the easiest of the war gases to protect against, however, and soon gas masks were a complete protection. A more effective gas was found in phosgene, which is a chemical combination of carbon monoxide and chlorine. Mustard gas was developed later, and chlorine is a very important element in it. Nearly all of the effective gases include chlorine.

At the beginning of the war phosphorus was not in use as a war material. At the end of the war its use had become only moderately extensive, but plans for a tremendous use of it were under way. Upon my arrival in France, I was assigned to organize the Gas Service as the Chemical

Warfare Service was then known. I visited the British and French gas headquarters, and I found that the British were using phosphorus in a four inch mortar, and that it was very effective. I learned from the French that they had been using all of the phosphorus that they could procure for artillery shells. They asked me if we could furnish a large supply of phosphorus. When it was found that we could not furnish the phosphorus, but had the phosphate rock, they even asked if we could ship the rock so that they might reduce it to phosphorus. In the fall of 1917, I submitted to the General Staff a request for 15,000 tons of phosphorus for use in the campaign of 1918. My estimate was cut to 3,500 tons, due to the fact that there was no possibility of obtaining the amount desired. I presume there was not a hundred tons made in a year in this country at that time. Phosphorus would have been of very great utility, not only against personnel to lower morale and cause casualties by burning, but it is the best smoke screen material we have. The burning quality and its smoke screening qualities were of the greatest importance. There were very few killed by it, yet the morale effect and the wounds were very great as we found in using Stokes mortar shells filled with phosphorus against German machine gun nests. It takes four men to take care of one wounded man, so that any wounding material that wounds large numbers and doesn't kill, is preferable to one that kills everybody it strikes. My requisition for 3,500 tons was never filled. We only procured seven or eight hundred tons up to the time of the armistice, and three-fourths of that was produced in Canada. We did not have the electrical furnaces or the power in this country to produce it on a larger scale.

Upon **Cross-Examination**, the Witness Testified as Follows:

The War Department has put into effect a plan for the mobilization of war materials. There is an effectively organized staff in the War Department under the immediate supervision of the Assistant Secretary of War. Section 5a of the Act of June 4, 1920 remains the basis of the plan of the War Department with reference to war materials. The country has been divided into procurement districts. One of the basic considerations of the plan is to encourage industry to be prepared to supply war needs and also to make plans to build up government facilities as well. The government has a large plant at Edgewood Arsenal for the production of chlorine, but that is now 17 years old and will in a few years, if not operated, become obsolete. That is a direct current process. For about a dozen chemical plants in Edgewood Arsenal, we spent approximately $40,000,000; the chlorine unit probably cost four or five million dollars. Probably a hundred thousand tons of chlorine is manufactured in the United States each year for commercial uses. Phosphorus is now manufactured for commercial uses but to a much less extent than chlorine. The peace time uses of phosphorus are only a fraction of what the war time uses would be. I do not know of any withdrawal by the War Department from its initial responsibility in the matter of planning and preparedness or of its delegation of that function to any other agency.

COLONEL CHARLES D. HARRIS,

Called as Witness on Behalf of Defendants Testified as Follows upon **Direct Examination**:

I am director of the Planning Branch of the office of the Assistant Secretary of War. I am in charge of the in-

dustrial phases of the work of planning for war in time of peace. In general terms, in the discharge of my duties it is necessary for me to become familiar with the procurement problems of the War Department. It is my task to coordinate and supervise the procurement work. The resources which must be organized are men and material, and contributory organization of power and transportation. Nitrate Plant No. 2 is a useful national defense facility. The availability of 10 to 15,000 tons of elemental phosphorus per annum would be a national defense asset. The availability to the War Department of 12,850 KV electric furnaces at Nitrate Plant No. 2 would be an important and useful national defense asset, if by that means we could supply the deficiency in "strategic materials" of which the normal domestic supply is not equal to the requirements. Research designed to make practicable the utilization of domestic materials on the "strategic" and "critical" list will assist the constituted authorities in solving their research problems. I have here a document approved by the War and Navy Departments entitled, "Industrial Mobilization Plan, Revised, 1933." That is the official mobilization plan of the armed forces of this country. The paragraph on page 12 of that document entitled, "Organization of Government Corporations," and the paragraph at the bottom of page 12 entitled "Power" are in the following language:

> "It will be advantageous in certain cases to organize corporations controlled or owned by the United States. These corporations will render services or take business risk which it would be unreasonable to expect from privately owned bodies. Examples of such corporations are Marine Insurance Corporations, War Finance Corporations, ship building corporations, power corporations, and corporations for trading in war materials. The supply of power to industry is

largely a local matter. Priorities, commandeering, and, if necessary, the forming of a government corporation to control local situations are among the measures which may be employed."

Those statements represent official policies of the mobilization plan, and also represent my own opinions. The matter of power is given considerable detailed attention and there is a separately organized power division. At this point, in connection with the witness' testimony, pages 24 and 25 of The Industrial Mobilization Plan were referred to; the matter contained therein is in substance as follows:

The mission of the Power Division is to insure an adequate supply of power necessary to war production with a minimum of interference with the normal production, distribution and use of power. The Power Division is to formulate policies for the purpose of alleviating power shortage, and through the cooperation of the power industries, to cause the installation of additional sources of power, when such additional installations can be installed within the time when they are needed. Among the functions of this Division is included, if and when necessary in order to prevent power shortages for war purposes, the formation of national power corporations, which wherever necessary will engage in the generation and distribution of power.

The War Department has divided the country into power zones. The Tennessee Valley is located in Power Zone Number 3, Districts 8 and 9. A small portion of the Valley in Kentucky is in Power Zone No. 2, District 4. Districts 8 and 9 are the Southeastern states and are considered together. In the course of my duties, I have collected data and information regarding generating capacity in various districts of the country. The purpose is

to know the conditions, and to be informed as to how much load can be placed upon various sections of the country. The information is systematically collected from many sources, including the power companies themselves. I have with me an abstract from the records in my office. The tabulation was made under my supervision, and was copied under my supervision from the official records in my office. I am familiar with those records and have charge of them. I have examined this copy and compared it with the records in my office, and can state that it is true and accurately copied with respect to Power Districts 8 and 9. (At this point the tabulations referred to were identified by the witness and introduced in evidence as defense Exhibit No. 96, which is omitted from this narrative.)

The availability of a possible expansion in time of war in generating capacity of approximately 150,000 KW prime power in Districts 8 and 9 would be a desirable and useful national defense asset. The development of facilities which would add to the power potentiality of the government owned plants at Muscle Shoals would be desirable from a national defense viewpoint. On December 21, 1934, I submitted to the Senate Munitions Committee a statement of the War Department policy of nationalization of industry in time of war. That statement was submitted in my official capacity and it represents the policy of the War Department. The following statements appearing upon pages 2, 11, 14, 15, 18 and 19 of the mimeographed copy that I have with me are parts of the statement of policy and conform to my opinion.

> "The War Department's policy in this matter agrees completely with the British policy regarding the same matter, as set forth by Sir John Simon in a statement before the British Parliament as follows:

'Our system for the supply of munitions of war to the Government combines a nucleus of State production with production by armament firms and private shipyards. A nucleus of State factories is useful not only for the weapons that they themselves produce, but as a check on the prices and qualities of those produced by private companies. The private armament firm has its skilled staff, its organization, its machinery—some of it extremely heavy and important. The armaments side of its business could not be maintained without foreign orders. If we are plunged into war, these armament firms and private shipyards are able to switch over rapidly from their level of peace production to their maximum of war production.'"

* * * * * *

"B. Productive Facilities in the United States.

1. Government Arsenals.

At present the Government has six manufacturing arsenals for the production of Ordnance supplies and one for gas defense equipment. There are no Government facilities for making airplanes or communications equipment. Edgewood Arsenal, which is operated by the Chemical Warfare Service, manufactures all gas masks used by the Army, Navy and Marine Corps. The six Ordnance arsenals manufacture all artillery, artillery and small arms ammuntion, rifles and pilot models of tanks and armored cars. After models have been adopted quantity production may be secured through competitive bids or undertaken at the arsenals, depending upon comparative costs and availability of facilities. The patented Browning automatic rifles and machine guns are purchased commercially. The arsenals produce about eighty-five per cent of the powder used by the Army. Only special powders for particular purposes are procured from

private sources. At present the arsenals are producing some explosives, but there are no facilities for manufacturing TNT, lead azide and mercury fulminate.

From the foregoing, it is apparent that with some expansion the arsenals could meet all peace time requirements except for aircraft and communications equipment. However, the maximum capacity of the arsenals is only a small part of the war requirements. Present war plans contemplate the maximum utilization of existing Government plants with such additions as are necessary to round out production. It is expected that such Government plants will be able to produce approximately the following percentages of the estimated war requirements of 12 vital items."

"Other Industrial Facilities.

"The total combined output of the existing Government arsenals and the so-called munitions industry will be inadequate to meet the munition requirement of a major war. Under present conditions, a large number of facilities engaged in the manufacture of strictly commercial items would be called upon to produce munitions. The extent to which existing facilities are adapted to the particular task will vary in each case. In practically all instances new machine tools will be required, and in most, some new machinery will be necessary. Many facilities will have to be converted, and a few entirely new plants will have to be erected. The shortage of properly equipped facilities presents one of the chief reasons why anticipated production of many important items will not meet requirements in the early months of a war.

"We may reasonably expect that in the event of war private plants would have fairly complete complements of personnel. One serious element of delay will be the unfamiliarity of the working forces with the manufacturing technique of noncommercial items.

This will be overcome somewhat by assigning to each facility an item or items as nearly as possible like its peace time products. It may be stated as axiomatic that an existing highly skilled organization can be instructed in a new manufacturing technique much more quickly than a new organization can be gotten together and trained."

"If, for reasons of policy, a decision is reached to manufacture all peace time requirements in Government plants, action along the following lines should be taken to offset to some extent the additional time that will be required to secure production from industry:

(a) Increase the War reserves of items that do not deteriorate and are not likely to become obsolete.

(b) Increase the manufacturing capacity of the arsenals, especially for the production of all types of ammunition. Moreover, all facilities should be kept in readiness to go into production. By utilizing regular personnel in key positions such an increase can be accomplished in a reasonable space of time. Any new construction should be located with due regard to security from hostile attack, distribution of products to any part of the country, raw materials, power, fuel, and labor. The expansion program for artillery ammunition should contemplate the utilizing of private industry for those operations that may be performed with standard machinery and little added training."

In case of a major war new plants would have to be built by the government or under government supervision. In the location of such additional facilities the considerations mentioned in the statement of policy are of material weight. The vulnerability to hostile attack,

transportation facilities, the availability of necessary raw materials, the availability of ready supplies of labor, the prevalence of an equable climate, and the availability of a quantity of electric power are all important factors. In my opinion the Tennessee Valley would be fairly safe from any hostile attack, and is located sufficiently close to industrial centers. In its plans, the War Department plans to use any surplus capacity existing in Power Districts 8 and 9, but that surplus capacity is not very large at the present time.

Upon **Cross Examination** the Witness Testified as Follows:

I did not make the computations as to generating capacity in Power Districts 8 and 9. Those figures are a part of the power plan of the War Department, which is on file in my office. I do not know what type of equipment or what companies are reflected in the peak generating capacity. I am not able to state the method by which the data was gathered. I do not know what year was taken either for generating capacity or actual peak load. Power District 8 includes Virginia, North Carolina and South Carolina; District 9 includes Tennessee, Georgia, Florida, Alabama and a portion of Mississippi. Power Districts 8 and 9 have always been considered together in the plans of the War Department on account of the interconnections of the two districts. We have not delegated to any other government agency the duty and obligation to go forward with planning for war purposes. All government departments cooperate when called upon. We will endeavor to use whatever the Tennessee Valley Authority has to offer. At the present time they have the Muscle Shoals Nitrate Plant, and they have electric power. So far nothing has been actually planned

with respect to the production of war materials by the Tennessee Valley Authority. Wherever possible, the general basis of our planning is to undertake to make peace time arrangements for industry to be in a stand-by condition to produce war materials. The chief reliance in time of war will be upon private industry. We have had satisfactory response from industry in anticipating war production. The country is divided into districts for that purpose. Captain McIntyre is stationed with the Ordnance Department in the City of Birmingham for that purpose. Competition by public agencies that would have an adverse effect on industry would adversely affect our plans; that has general application. Our plans contemplate the full utilization of all government facilities for production and place the remainder of the load on industry. The Planning Section has not approved or recommended any program under which the government plants are to enter into commercial production of commodities in competition with industry. I do not think that the fact that a governmental facility might be under long term contracts for commercial use would affect the situation very seriously, because any such obligation would be set aside in war. The Planning Section has not been advised of any contracts for the commitment of power generated at Muscle Shoals. I do not know whether the Tennessee Valley Authority has reported its plans with respect to the sale of power to the War Department. I do not know that anybody representing the Tennessee Valley Authority has conferred with anyone in the Planning Section as to whether its plans and program are consistent with our plans. I have not discussed any plans with Dr. Morgan or Mr. Lilienthal or Dr. Harcourt Morgan. I have discussed them with Dr. Curtis. So far as I know, neither the distribution of phosphates to the

general public or the sale of power has been taken up with the Planning Section. I had a part in the drafting of the report of the Assistant Secretary of War for the fiscal year ending June 30, 1934, in so far as it related to the duties of planning for war. There is no mention in that report of the Tennessee Valley Authority.

The figures set out on Defense Exhibit No. 96 represent a prediction. The table is taken from a power study prepared by the Chief of Engineers of the United States Army, and submitted to the office of the Assistant Secretary of War. That is a prediction made on the best data available. I do not know the data upon which that report was prepared. The statement shows a capacity that is normally used, and the excess capacity of that normal use. I do not know what units are reflected in the study. District 9 includes the State of Virginia and the entire Atlantic seaboard, and the State of Florida. It excludes Kentucky and West Virginia. In our plans for power we contemplate that it may be necessary to finance power companies and perhaps to finance the building of plants for expansion. The government did build a steam generating plant in the State of Alabama in the vicinity of Gorgas. The original contract provided that at the conclusion of the war that plant should be sold to the Alabama Power Company, which was done. I do not know of my own knowledge whether the studies as to power took into consideration the availability of the recently completed natural gas lines from Munroe and the Richland fields and the Jackson fields to Atlanta. Certain parts of this study were shown to a representative of the Tennessee Valley Authority in connection with this suit, but not the portions that are confidential in relation to the individual companies. It is not true that we declined to give any information until a peremptory order was

issued. There was no peremptory order of any kind. Several of the legal staff of the Tennessee Valley Authority were in Washington, and a portion of the report was shown to one of them by me. In a preliminary way representatives of the Tennessee Valley Authority have conferred with us with reference to the national defense. The Tennessee Valley Authority is a very young organization. We do not count our chickens until they are hatched, but we have taken cognizance of the Tennessee Valley Authority and its possibilities.

Upon **Redirect Examination** the Witness Testified as Follows:

I had a preliminary discussion with Dr. Curtis in connection with the possibilities of developments at Muscle Shoals. We have not made definite plans because Tennessee Valley Authority is not yet orientated, so that we can interpret them in our plan so far as a definite program is concerned. Dr. Curtis has discussed with me such matters as phosphorus, ammonium nitrate and manganese and possible substitutes for other war materials.

Upon **Recross Examination** the Witness Testified as Follows:

In the conversation with Dr. Curtis the question of the production of alloy steels and the concentration of manganese was mentioned. The possibilities of research and the possible utilization of equipment at Muscle Shoals was discussed.

At this point the attention of the Court was called to certain extracts from the official reports of the Bureau of Reclamation for the purpose of showing an existing government practice with reference to the generation and sale

of hydro electric power. The excerpt beginning on the top of page 5 of the **Annual Report** of the Commissioner of Reclamation to the Secretary of Interior for the fiscal year ending June 30, 1932 was in substance as follows:

During the fiscal year the Bureau constructed 3,308 miles of transmission lines from the dams.

The extract appearing on page 12 of the report for the fiscal year ending June 30, 1932, was in substance as follows: On certain projects the water users are relieved from repaying the cost of a part of the irrigation works which are to be repaid out of revenues from the sale of power. On one of these projects, the net revenue from the sale of commercial power is larger than the contract payments required from landowners. Twenty hydro-electric power plants were in operation during the fiscal year, with a total installed generator capacity of 102,550 KW and they generated 331,739,500 KWH of energy, of which 21% was utilized for irrigation and drainage pumping; 65.4% was sold for commercial and industrial uses and the remainder or 13.6% was used for miscellaneous purposes and consumed by losses. Nine of these plants, having a total installed capacity of 31,500 KW were operated by the government.

The table appearing on page 101 of the Annual Report for the fiscal year ending June 30, 1932, which is Reclamation Table No. 19, entitled, "Power Plants, Operated on Bureau of Reclamation Projects During Fiscal Year 1931 to 1932," was called to the attention of the Court, and is here set out in words and figures, since in the opinion of the Court it is impracticable to reduce this table to narrative form.

RECLAMATION TABLE 19.—*Power plants operated on Bureau of Reclamation projects during fiscal year 1931-32*

Project	Name of plant	Outgoing line voltage	Plant capacity (kilovolt-amperes)	Number of units	Head in feet	First cost of plant	Cost of operation and maintenance	Estimated depreciation	Cost per kilowatt-hour exclusive of depreciation	Distribution of kilowatt-hours generated				Total output, kilowatt hours [2]	Gross power sales
										Sold to consumers	Irrigation and drainage requirements	Used for other purposes	Losses		
Boise	Black Canyon	[1] 66,000	10,000	2	74-86	$414,317.21	$10,350.01	$15,291.07	$0.00029	12,388,000	23,247,000	661,000	.....	[3] 36,296,500	$83,138.51
	Boise River	22,000	1,875	3	20.4-23.7	167,905.37	3,372.65	5,876.69	.00307	.....	1,097,701	.....	.....	1,097,701	8,533.94
Minidoka	Minidoka	33,000	10,000	6	46.77	784,778.13	24,764.74	24,396.00	.00043	[3] 19,857,077	[4] 26,053,710	8,910,874	4,065,366	58,245,000	164,871.51
	American Falls (2 plants). [5]	33,000	540	1	44	[6] 76,075.00	.....	.....	.....	.....	.....	.....	.....	.....	.....
Newlands [6]	Lahontan [7]	33,000 66,000 2,300	1,875	3	105-110	141,586.01	6,230.50	4,260.00	.00290	1,428,900	98,703	621,627	.....	2,149,240	7,412.14
North Platte	Guernsey	33,000	6,000	2	70-90	454,244.27	13,844.20	8,035.00	.00102	19,934,138	12,920	305,373	2,128,839	13,550,000 8,825,250	344,050.22
Rio Grande	Lingle	33,000	1,750	4	106	184,791.74	12,508.75	5,200.00	.00142						
	Elephant Butte.	2,300	150	1	18-180	8,440.50	1,970.04	None.	.022	None.	None.	90,800	Unknown.	90,800	None.
Riverton	Pilot Butte	33,000	2,000	2	103	218,962.14	25,406.11	7,800.00	.01737	1,005,730	None.	267,595	189,615	1,462,940	22,623.77
Salt River	Horse Mesa	110,000	33,300	3	265	754,885.13	32,047.97	37,744.25	.00035	[3] 185,484,347	[3] 22,372,620	[3] 167,437	[3] 33,200,790	91,229,000 23,059,000 22,200,000 31,103,000 11,755,600 7,497,400 2,487,925 2,953,410	2,094,616.40
	Roosevelt	110,000	19,250	7	70-240	1,235,894.58	60,091.92	61,794.73	.00261						
	Stewart Mountain.	45,000	13,000	1	35-114	320,371.98	12,486.24	16,018.60	.00056						
	Mormon Flat.	110,000	8,750	1	40-150	482,767.80	12,539.54	24,138.39	.00040						
	Crosscut	[8] 11,000 40,000	5,250	6	111	755,147.29	20,075.70	37,757.36	.00171						
	South Consolidated.	40,000	2,000	2	34	163,139.60	10,822.63	8,156.98	.00144						
	Arizona Falls.	11,000	1,060	2	19	109,500.73	8,075.24	5,475.04	.00325						
	Chandler	11,000	600	1	40	91,990.84	8,690.00	4,599.54	.00294						
Shoshone	Shoshone	33,000	7,000	3	220	746,505.72	13,168.38	26,085.42	.00245	4,529,170	None.	87,889	761,651	5,378,710	89,962.83
Strawberry Valley. [9]	Spanish Fork	11,000	1,000	2	123.5	60,904.80	20,634.70	3,627.48	.00660	2,833,479	None.	11,334	283,348	3,128,161	38,824.24
Yakima-Sunnyside. [9]	Rocky Ford	6,600	187	1	73	23,000.00	2,478.24	1,056.40	.00497	None.	400,000	None.	None.	400,000	None.
Yuma	Siphon Drop	33,000	2,000	2	9.88	317,936.09	12,212.38	13,248.00	.00139	7,275,404	1,023,076	88,783	379,586	[3] 8,766,849	68,426.52

[1] 6,600-volt generators; all others 2,300 volts except as noted.
[2] Entire output delivered to Idaho Power Co.
[3] West Side plant operated only in case of emergency; not operated since 1927. Island plant dismantled, first cost included.
[4] Estimated.
[5] Includes purchased power.
[6] Operated by irrigation district or water users' association.
[7] Operated by Sierra Pacific Power Co. under lease assigned by Canyon Power Co.
[8] 11,000-volt generators.
[9] All 8 power plants feed into the same distribution system.

The document entitled, "United States Department of Interior, Bureau of Reclamation, Annual Report of the Secretary of the Interior for the Year 1928" was called to the attention of the Court, and the tables appearing on pages 46-67, which are Reclamation Tables No. 11 and No. 14 were specifically referred to. Those tables are set out here in words and figures, since it appears to the Court it would be impracticable to reduce their contents to narrative form.

RECLAMATION TABLES NOS. 11-14.—*Engineering data for projects on completion*—Continued

NO. 14. IRRIGABLE AREA, PRESENT STATUS

State, project, and division	Public land			State land unsold	Indian land	Private land		Total
	Entered	Open	Withdrawn			Railroad unsold	Other	
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Arizona:								
Salt River	20,571[1]						219,629	240,200
Gravity System	13,412						219,629	233,041
Pumping system	7,159							7,159
Arizona-California: Yuma	14,632	3,504	34,274		8,325		51,337	112,072
Arizona—								
Valley	5,829		1,875		110		44,340	52,154
Mesa	2,815	3,504	31,884				6,797	45,000
California—Reservation	68		515		8,215		200	14,918
California: Orland—Main							[2]20,733	[2]20,733
Colorado:								
Grand Valley	13,530	361	8,494				28,115	50,500
Garfield gravity	11,530	361	4,994				15,115	32,000
Garfield pumping	2,000		3,500				3,000	8,500
Orchard Mesa pumping							10,000	10,000
Uncompahgre	13,144	1,429					61,211	75,784
Idaho:								
Boise	69,468		17,320	6,850			251,860	345,498
Arrowrock (Idaho)	65,892			60			203,859	269,821
Arrowrock (Oregon)	1,206						5,697	6,903
Notus							6,874	6,874
Hillcrest	1,000		2,000	1,000			10,100	14,100
Black Canyon	1,370		15,320	5,790			25,320	47,800
King Hill				335			16,553	16,888
Minidoka	96,080	618	146,840	9,224			63,471	316,233
Pumping	30,258			1,013			17,689	48,960
Gravity	65,822	618		371			5,782	72,593
North side pumping extension			106,840	7,840				114,680
Gravity extension unit			40,000				40,000	80,000
Montana:								
Huntley	26,213		2,553		244		3,497	32,507
Gravity	21,272		2,007		244		3,497	27,020
Pumping	4,941		546					5,487
Divisions—								
Pryor	23,549		1,889		66		2,912	28,416
Eastern	925		42		178		585	1,730
Ply Creek	1,739		622					2,361
Milk River	28,940		14,425	5,541			94,382	143,288
Chinook division [3]	1,941		1,608	1,198			50,753	55,500
Malta division	21,273		12,365	3,280			28,737	65,655
Glasgow division	5,726		452	1,063			14,892	22,133
Sun River	38,113		34,555	5,182			28,992	106,842
Sun River Slope	655		13,341	969			3,213	18,178
Big Coulee				356			1,934	2,290
Greenfields	22,071		18,768	3,640			20,184	64,663
Mill Coulee	4,197		1,543				2,160	7,900
Fort Shaw	11,190		903	217			1,501	13,811
Montana-North Dakota:								
Lower Yellowstone	9,869		2,169	798		211	46,302	59,349
Montana	4,625		1,086	658		211	32,448	39,028
North Dakota	5,244		1,083	140			13,854	20,321
Divisions—								
Gravity	9,708		2,169	565		203	44,396	57,041
Pumping	161			233		8	1,906	2,308
Nebraska-Wyoming:								
North Platte	56,777		4,420	3,463			172,697	237,357
Interstate division	10,793		2,424	644			100,589	114,450
Nebraska	10,042		2,239	644			98,635	111,560
Wyoming	751		185				1,954	2,890
Fort Laramie division	38,298		1,996	2,780			63,659	106,733
Nebraska	15,420		489	246			39,073	55,228
Wyoming	22,878		1,507	2,534			8,449	51,505
Newport division—								
Nebraska	7,686			39			8,449	16,174
Nevada:								
Newlands	29,308	554	17,512		4,877	7,500	30,249	90,000
Carson division	25,827	433	12,114		4,877	2,500	27,249	73,000
Truckee division	3,481	121	5,398			5,000	3,000	17,000
New Mexico: Carlsbad	45						25,010	25,055

[1] Includes 416 acres of vested rights and 170 acres of school and town sites.

[2] Includes Savoy unit previously excluded.

RECLAMATION TABLES NOS. 11-14.—*Engineering data for projects on completion*—Continued.

NO. 14. IRRIGABLE AREA, PRESENT STATUS—Continued.

State, project, and division	Public land			State land unsold	Indian land	Private land		Total
	Entered	Open	Withdrawn			Railroad unsold	Other	
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
New Mexico-Texas:	550			200			154,250	155,000
Rio Grande	550			200			87,250	88,000
New Mexico							67,000	67,000
Texas:								
Divisions—								
Rincon				50			16,950	17,000
Leasburg	300			100			32,600	33,000
Mesilla	250			50			47,700	48,000
El Paso							57,000	57,000
Oregon:								
Umatilla	2,383		2,376			3,319	14,353	22,431
East division						1,407	9,724	11,131
West division	2,383		2,376			1,912	4,629	11,300
Vale			3,700				27,300	31,000
Oregon-California: Klamath	13,913	405	20,982				141,449	176,749
Oregon	3,981						104,106	108,087
California	9,932	405	20,982				37,343	68,662
Divisions—								
Main	2,536						39,221	41,757
Tule Lake	11,377	405	20,982				236	33,000
Pumping							20,595	20,595
Langell Valley							21,497	21,497
Bonanza Springs							5,900	5,900
Lower Klamath Lake							[33] 54,000	54,000
Oregon-Idaho: Owyhee	27,000		7,000	3,000			85,000	122,000
Idaho, complete supply	3,000		7,000				35,000	45,000
Oregon—								
Complete supply	24,000			3,000			38,000	65,000
Supplemental right							12,000	12,000
South Dakota: Belle Fourche	36,312		4,508	1,820			38,670	81,310
Utah:								
Strawberry Valley	2,003						51,886	53,889
High Line	2,003						19,853	21,856
Spanish Fork							22,033	22,033
Springville-Mapleton							10,000	10,000
Salt Lake Basin							80,000	80,000
Washington:								
Okanogan	116						7,184	7,300
Gravity								6,125
Pumping								1,175
Yakima	7,358		14,231	6,494	241	24,522	288,854	341,700
Sunnyside	2,627			30	241		104,702	107,600
Tieton	2,048			4			29,948	32,000
Kittitas			5,533	1,961		6,729	57,777	72,000
Ross	120		1,523	2,067		11,310	43,330	58,350
Moxee	1,663		775	1,332		2,783	30,197	36,750
Kennewick	900		6,400	1,100		3,700	22,900	35,000
Wyoming:								
Riverton			69,000		1,000		30,000	100,000
Shoshone	53,895	13,298	110,989	3,880		7,027	14,078	203,167
Montana, Frannie division			86	4				90
Wyoming—								
Garland division	37,429	728	1,290	252			2,362	[34] 42,061
Frannie division	14,272	1,143	10,264	311		356	1,564	27,910
Willwood division	1,976	1,164	8,180	282			330	11,932
Heart Mountain division	218	10,263	38,582	1,958		6,671	9,822	[35] 67,514
Oregon Basin division			52,587	1,073				53,660
Total	560,220	20,169	515,348	46,787	14,687	42,579	2,047,062	3,246,852

[33] Includes some public land, but distribution not known.

[34] Increase from 41,923 acres reported in twenty-fifth annual report is class-6 land for which owners have not accepted adjustment.

[35] Increase from previous report due to inclusion of lands in Chapman Bench and Polecat Bench.

The table appearing on page 50 of the same volume, which is Reclamation Table No. 16, and the table appearing on page 51, which is Reclamation Table No. 17 were referred to. These tables are here reproduced in words and figures since it appears to the Court that it is impracticable to reduce their contents to narrative form.

RECLAMATION TABLE 16.—*Power plants operated on Bureau of Reclamation projects during fiscal year 1927-28*

Project	Name of plant	Outgoing line voltage	Plant capacity (kilovolt-amperes)	Number of units	Head in feet	First cost of plant	Cost of operation and maintenance	Estimated depreciation	Cost per kilowatt-hour exclusive of depreciation	Distribution of kilowatt-hours generated				Total output, kilowatt-hours	Gross power sales
										Sold to consumers	Irrigation and drainage requirements	Used for other purposes	Losses		
Boise	Black Canyon[1]	b 66,000	10,000	2	82-92	$414,317.21	$11,918.00	$14,501.00	0.000221	Entire output delivered to Idaho Power Co.				53,919,494	$48,677.32
	Boise River[2]	22,000	1,875	3	25-30	167,905.37	235.36	3,000.00	.01	Entire output leased to Idaho Power Co.				23,800	4,000.00
Minidoka	Minidoka	33,000	10,000	6	47	645,403.41	37,556.03	20,400.00	.00072	20,384,789	28,631,474	108,769	2,578,672	51,696,504	125,872.85
	American Falls (2 plants).[2]	33,000	1,540	3	36 & 45	*76,975.00	[3]6,070.57	.....	.....	Distribution included with Minidoka power plant.				7,200	.....
Newlands[7]	Lahontan[4]	33,000	1,875	3	105 & 110	141,886.01	.....	4,260.00	.....	6,406,148	.....	90,622	.....	6,496,770	22,985.48
North Platte	Guernsey	33,000	6,000	2	Variable	[5]440,933.21	[6]43,947.81	45,800.00	.0029	12,999,324	.....	228,680	1,912,476	[6]15,140,481	182,133.88
	Lingle	33,000	1,750	4	107	186,693.34									
Okanogan	Power Plant No. 1.	6,600	187	1	108	11,923.44	Not operated during year.								
	Power Plant No. 2.	6,600	187	1	55	13,931.42									
Rio Grande	Elephant Butte No. 2	2,300	150	1	18-180	8,440.50	2,033.65	253.00	.04	.....	.....	50,440	.....	50,440	.....
Riverton	Pilot Butte	33,000	1,000	1	103	153,804.03	22,162.15	2,761.33	.0253	518,794	.....	250,296	106,190	875,280	11,103.01
Salt River[7]	Arizona Falls	a 11,000	1,060	2	19	109,500.73	11,893.80	5,475.00	.00391					3,038,475	
	Chandler	11,000	600	1	40	91,990.84	8,797.90	4,600.00	.00342					2,573,610	
	Crosscut	a 11,000 & 40,000	5,250	6	111	755,147.29	27,412.38	37,750.00	.00224					12,262,000	
	Roosevelt	110,000	19,250	7	80-240	1,235,894.58	58,318.16	61,850.00	.000895	[8]203,762,191	27,005,457	408,340	29,821,633	65,149,062	2,157,940.91
	South Consolidated.	40,000	2,000	2	34	163,139.60	10,791.72	8,160.00	.00134					8,042,300	
	Mormon Flats	110,000	8,750	1	60-150	482,767.80	13,503.03	24,130.00	.000362					37,255,000	
	Horse Mesa	110,000	33,000	3	265	5,341,896.54	56,742.90	267,000.00	.000435					128,770,000	
Shoshone	Shoshone	33,000	2,000	2	225	567,698.96	9,788.00	16,914.00	.00376	1,811,164	.....	193,459	597,037	2,601,660	31,447.53
Strawberry Valley.[7]	Spanish Fork	11,000	1,000	2	123.5	60,904.80	14,803.20	3,045.00	.0078	1,580,678	.....	189,898	132,884	[9]1,903,460	32,204.98
Yakima-Sunnyside.[7]	Rocky Ford	6,600	187	1	73	23,000.00	2,521.87	1,056.40	.00397	.....	634,800	.....	.....	634,800	.....
Yuma	Siphon Drop	*33,000	2,000	2	9.37	319,425.00	*17,775.00	*11,700.00	*.00295	*4,305,656	*1,363,712	*146,704	*321,503	[10]6,137,575	*58,292.29

[1] Operated entire fiscal year.
[2] Operated for stand-by service only.
[3] Includes $5,716.26 rental charges.
[4] Leased to Canyon Power Co. for 10-year period.
[5] Cost not final.
[6] Includes purchased power.
[7] Operated by irrigation district or association.
[8] Includes 158,640 kilowatt-hours generated by Springville plant.
[9] Includes 119,241 kilowatt-hours purchased.
* Estimated.
a 11,000 volt generators.
b 6,600 volt generators; all others 2,300 volts.

C. P. ALMON, JR.

Called as Witness for Defendants Testified upon **Direct Examination** as Follows:

My present residence is Wilson Dam, Alabama, and I am Assistant Superintendent of Power with the Tennnessee Valley Authority. I am an electrical engineer by profession. I graduated from the University of Alabama, in electrical engineering in 1928. I have had two years experience in electrical construction work with the United States Engineers at Wilson Dam; three months with an electrical constructing concern at Florence, Alabama; three months of electrical switchboard and wiring work with the Dixie Construction Company at Martin Dam; hydro electric system studies with the Southeastern Engineering Company and two years in the power system study section of the Southeastern Engineering Company. For approximately three years I was with the operating department of the Tennessee Electric Power Company. I have been with the Tennessee Valley Authority for approximately one year and three months. I am in charge of all the operations at Wilson Dam and the Sheffield Steam Plant. I have made a study of the operation of Wilson Dam and the other electric properties at Muscle Shoals prior to the time they were taken over by the Authority. I procured my information from the daily operating books and the daily operating log sheets at Wilson Dam. The total amount of power available at Wilson Dam during the period from 1926 through 1933 was as follows:

1926	936,300,000 KWH
1927	763,500,000
1928	1,339,400,000
1929	1,349,000,000
1930	801,200,000
1931	836,600,000
1932	1,141,900,000
1933	960,400,000

The amount of power that was sold at Wilson Dam during those years was as follows:

1926	432,629,000
1927	557,025,000
1928	216,859,000
1929	165,825,000
1930	299,260,000
1931	339,424,000
1932	280,619,000
1933	280,844,000

The only purchaser of that power during those years was the Alabama Power Company.

The chart entitled, "Necessity for Transmission Lines, Basic Data by C. P. Almon, Jr.," was prepared by me and the writing upon it represents my testimony in this case.

(At this point the above described chart was identified

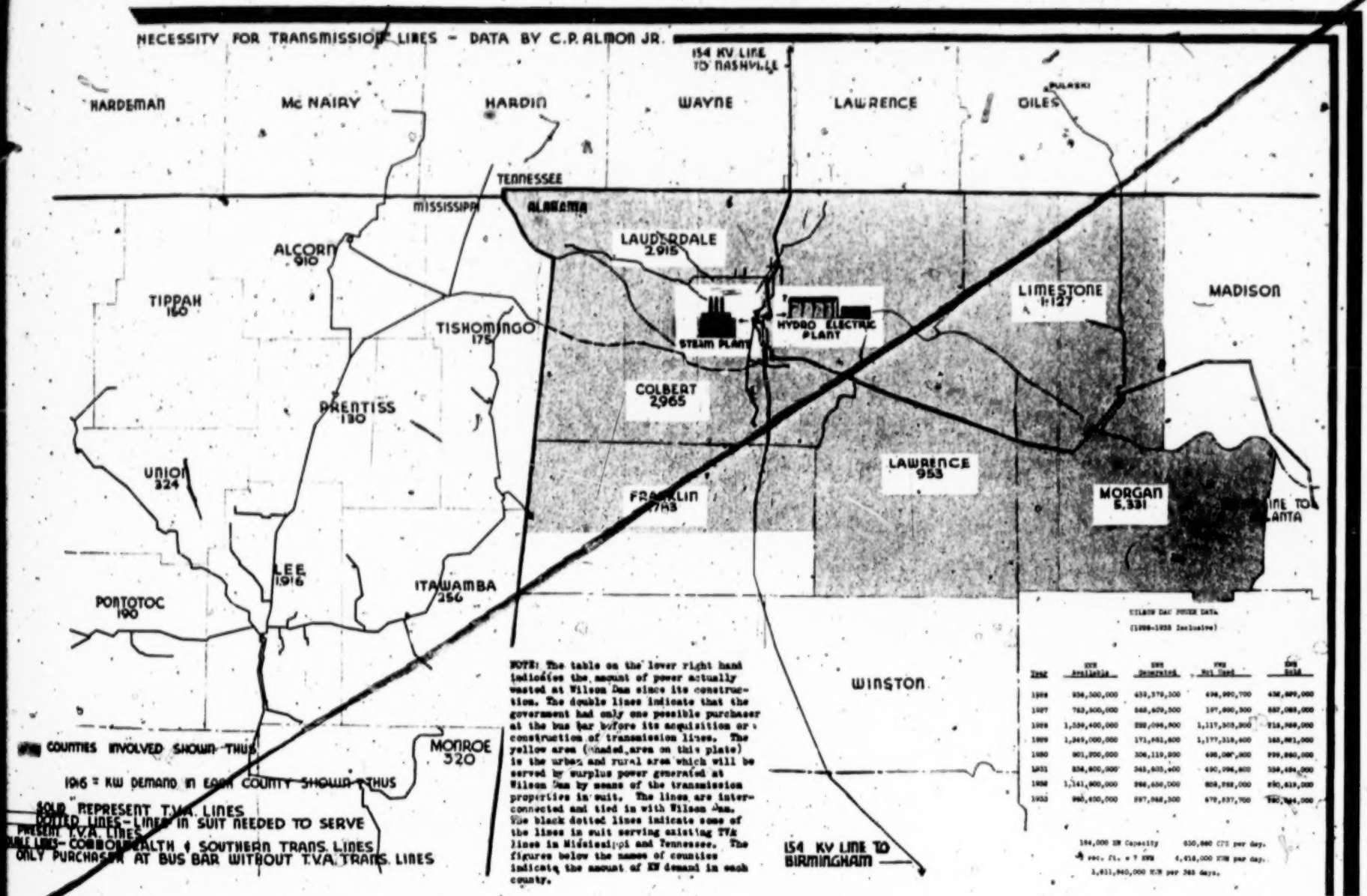
and offered in evidence as defense Exhibit No. 97, which is reproduced upon the opposite page).

The amount of power generated at Muscle Shoals during the period from 1926 to 1933 was as follows:

1926	439,379,300 KWH
1927	565,609,500
1928	222,960,800
1929	171,681,600
1930	306,119,200
1931	346,603,400
1932	286,638,000
1933	287,862,300

The figures upon the chart under the heading, "Power Not Used" represents the amount of power that was available and could have been sold but was not sold during those years. The figures are correct. The installed capacity at Wilson Dam is 184,000 KW. Power generated at Muscle Shoals is being used at the present time for various governmental purposes. At Wilson Dam we are using it for the lighting and heating of the plant, running the elevators and other miscellaneous uses. Power is being used in the same manner at the Sheffield Steam Plant. It is also being used at the Wilson Dam villages which are called 1, 2 and 3. It is used for lock operations by the United States Engineers. It is also being used in construction work and at the Wheeler Dam village. The same thing is true at Norris, where we are using the power for the Town of Norris and in the construction work. An important use is at the fertilizer plant at Nitrate Plant No. 2. We have an office building at Chattanooga to which we supply the power. Those uses will continue over the period of the next few years. There will be a

Defense Exhibit No. 97.



NOTE: The table on the lower right hand indicates the amount of power actually wasted at Wilson Dam since its construction. The double lines indicate that the government had only one possible purchaser at the bus bar before its acquisition or construction of transmission lines. The yellow area (shaded area on this plate) is the urban and rural area which will be served by surplus power generated at Wilson Dam by means of the transmission properties in suit. The lines are interconnected and tied in with Wilson Dam. The black dotted lines indicate some of the lines in suit serving existing TVA lines in Mississippi and Tennessee. The figures below the names of counties indicate the amount of KW demand in each county.

WILSON DAM POWER DATA

(1926-1933 Inclusive)

Year	KWH Available	KWH Generated	KWH Not Used	KWH Sold
1926	936,500,000	439,579,300	496,920,700	438,899,000
1927	763,505,000	566,609,500	197,000,500	557,085,000
1928	1,330,400,000	392,096,800	1,117,303,200	716,960,000
1929	1,349,000,000	171,661,600	1,177,338,400	168,981,000
1930	801,200,000	306,119,000	495,087,000	299,880,000
1931	836,800,000	341,635,400	490,996,600	336,684,000
1932	1,241,800,000	986,650,000	809,788,000	980,619,000
1933	960,450,000	397,868,300	672,837,700	780,744,000

154,000 KW Capacity 630,860 CFS per day.
4 sec. ft. = 7 KWH 4,418,000 KWH per day.
1,611,940,000 KWH per 365 days.

greater demand for power for the fertilizer works, and there will also be demand for power on the construction work at other projects. When the construction of Pickwick Dam begins they will require a considerable amount of power. The total used for these various purposes during 1934 was 40,770,186 KWH. That amount has increased during the last seven months. The amount of power generated at Wilson Dam during the period from July 1, 1934 through January 31, 1935 was 55,189,200 KWH. Approximately 68% of the power generated by the Tennessee Valley Authority at Wilson Dam has been used for these specified purposes in the last seven months.

I have had the load dispatcher at Wilson Dam investigate the present load in the North Alabama area covered by the contract of January 4. The counties involved in this territory are shown upon defense Exhibit No. 97 in the yellow background. (In the reproduction this is shaded background). The territory includes Lauderdale, Limestone, Morgan, Lawrence, Colbert and roughly the north half of Franklin. The figures upon the exhibit under the names of the counties represent the existing demand in the different counties. Our dispatcher obtained those figures from the Alabama Power Company. The demand in the Mississippi counties that are being served by the Tennessee Valley Authority are shown upon defense Exhibit No. 97. The green lines upon the map represent the Tennessee Valley Authority lines in Mississippi (Solid lines in reproduction). The red line is the 154 KV line of the Tennessee Electric Power Company. They tie in directly with Wilson Dam. (Double lines in reproduction). This other red line here (indicating on the chart defense Exhibit No. 97) is the line into the Alabama Power Company system. (Double lines in reproduction). It ties in di-

rectly with Wilson Dam. This red line (indicating on the chart defense Exhibit No. 97) is a 110 KV line of the Alabama Power Company, which ties in directly with the Tennessee Valley Authority line at the Sheffield Steam Plant. The black dotted line running from the Sheffield Steam Plant south about six miles, and thence west to the Mississippi State line through Colbert County, is one of the necessary sources of power for this Mississippi area. The green line on the map running south from the Steam Plant goes into Colbert County, and is a Tennessee Valley Authority line serving rural customers. The green lines in Lauderdale are Tennessee Valley Authority lines serving rural customers. Those lines are supplied by the black dotted line running from the Sheffield Steam Plant. The existing demand in the area covered by the contract of January 4 is approximately 15,074 KW. That demand can be served by power generated at Wilson Dam alone. The entire territory covered by the contract of January 4 can be served by power from Wilson Dam. In order to serve that territory from Wilson Dam the lines included in the contract of January 4 or substantially duplicate lines are necessary. The transmission lines included in the contract of January 4 are interconnected with Wilson Dam. It would not be necessary to interconnect those lines with any other dam in order to serve this area.

The line from the Sheffield Steam Plant shown on defense Exhibit 97 goes south approximately five miles, thence west to the Mississippi State line through Colbert County and then into three northeast Mississippi Counties. It is one of the lines included in the contract of January 4. All of the lines included in that contract are interconnected with the interstate transmission system of the Alabama Power Company or affiliated companies. The network of the Alabama Power Company is intertied with the net

works of other power companies outside of the State of Alabama. Energy generated within the State of Alabama is transmitted over those lines to other states.

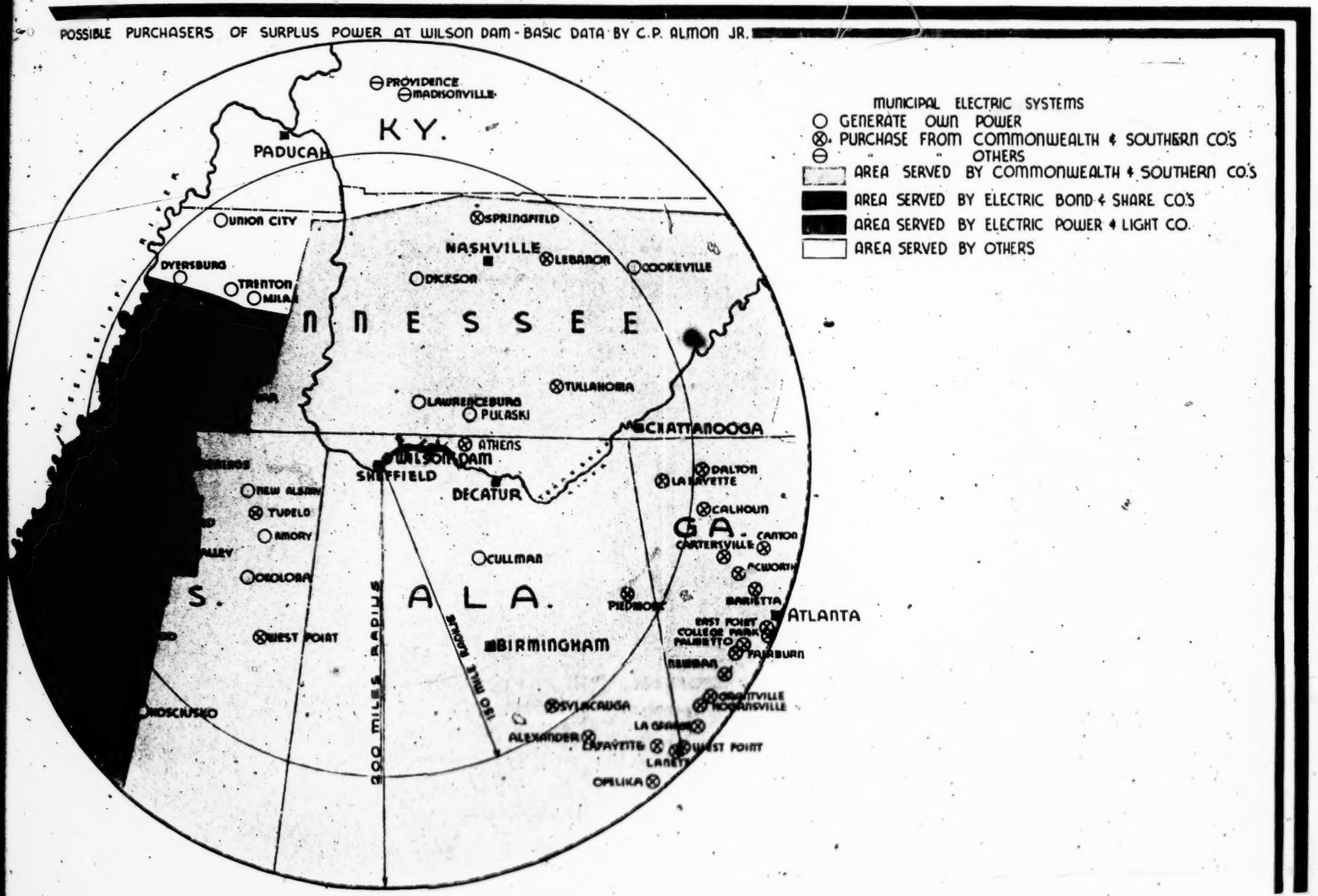
The properties located in northeast Mississippi have been transferred from the Mississippi Power Company to the Tennessee Valley Authority, and are now being operated by the Authority. Those are the ones shown on defense Exhibit No. 97 and described in the contract of January 4. The system in Alcorn County has been transferred to the Alcorn County Electric Association. There are certain properties in the vicinity of Tupelo, Mississippi that have been transferred to the City of Tupelo, and the Pontotoc properties were transferred just recently. These properties in Mississippi are being served through the interchange agreement set out in the contract of January 4. An interchange agreement is a way of disposing of power. It is a way of getting power into that territory. We are generating a certain amount of power at Wilson Dam and it is put on the lines of the Alabama Power Company. That power is delivered to this section of Mississippi. Of course, it is metered at the interchange point which is at Okolona. According to the contract, we deliver to the power companies 15% in KWH additional to the amount of power that we know is going into this particular area. That 15% is generated at Wilson Dam to off-set transmission losses. We actually deliver to the power company an equivalent of the power that is delivered to us over here at the interchange point. That is the method of getting the power into this territory. In order to serve the Mississippi properties with power generated at Wilson Dam, it is necessary to have the use of transmission lines into this territory. The source of power to the Mississippi properties is in the State of Alabama. In order to obtain the necessary transmission

line connections, you could build a line, purchase one, or lease one, or you might serve the property by interchange agreements. Those are the only ways of getting to the territory. It would be necessary to use one of those four methods in order to dispose of surplus power generated at Wilson Dam in the Mississippi territory.

The generating plants in the Mississippi territory mentioned in the testimony of Mr. Perkins are shut down at the present time. They are being held in a stand-by condition to be used if emergency arises. Such stand-by equipment is necessary under existing conditions. At the present time Tennessee Valley Authority is not purchasing any power for resale. I suppose that the reason why the boilers in the plants inspected by Mr. Perkins were warm was that they had just been heated up to keep the water from freezing. The Tennessee Valley Authority is not at present operating any isolated generating plants.

Under existing conditions, the only possible purchasers of power in large blocks at the generating plant would be the power companies; that is, the Alabama Power Company and possibly the Tennessee Electric Power Company. Both of those companies are affiliated with the Commonwealth and Southern Company. At the present time they are the only possible purchasers. The chart entitled, "Possible Purchasers of Surplus Power at Wilson Dam" was prepared under my supervision and direction. The basic information was supplied by me, and everything that appears upon the chart, including the writing, is substantially correct and represents my testimony. (At this point the chart referred to above was identified and offered in evidence as defense Exhibit No. 98, which is reproduced upon the opposite page). In this chart we have taken Wilson Dam as the center of the circles, and we have drawn one of 150 miles radius and the other with a radius of 200

Defense Exhibit No. 98.



miles. In those circles we have shown the operating companies, the areas served by the Commonwealth and Southern Company is shown in yellow. (Light shaded area in dotted border in reproduction). The area served by the Electric Bond and Share Company is shown in blue. (Dark shaded area in reproduction) The area served by the Electric Power and Light Company is shown in green. (Light gray area in reproduction) Also upon this chart we have shown the municipal systems. The full circles without any crosses or bars through them show the systems which generate their own power. The cross in the small circles shows which of the municipal systems purchase from the Commonwealth and Southern Company. Those with the circle with the bar through it are the municipal systems served by others. The area served by others besides the power companies that have been mentioned is represented in white on this chart. I don't believe that any of the municipal distribution systems shown on this chart within the radius of 150 miles are in a position to afford to construct a transmission line to Wilson Dam. The cost of building the line would not be justified. The load of the municipal systems within that radius is very small in comparison to the total load. Approximately 77% of the population within that radius is being served by the Commonwealth and Southern Company. In my opinion, the only possible purchasers of power who could afford to construct transmission lines to Wilson Dam are the Electric Bond and Share Company, the Electric Power and Light Company, and a small area in north Mississippi and Tennessee. It would not be feasible to serve construction work and other government property by energy from Wilson Dam without either building or acquiring or using transmission lines. There is no major competition between supplies of electricity in that area within 150 miles of

Wilson Dam. There is quite a large area surrounding the lines included in the contract of January 4 where rural service could be built up. Unless the transmission lines from the dam are acquired it would be necessary to substantially duplicate them in order to get into the rural territory.

There is no clear cut distinction from a functional and organization standpoint between generation and transmission. Norris Dam will not produce any firm power. Power will not be generated there at all times, because there are certain periods of the year when it will be necessary to store water. Assuming a proper interconnection between Norris Dam and Wilson Dam, the operation of the two generators at Norris, when they are installed, would transform some of the secondary power at Wilson into firm power.

I am familiar with the situation with respect to the Carolina Power and Light Company contract. That contract is contingent upon the Tennessee Public Service Company contract, and those contracts have not been carried out and are no longer in force. I would consider the Belle Mina and Rodgersville property as distinctly different from the urban distribution systems located in the north Alabama area. One is an isolated line and the other is a network of lines.

Upon **Cross Examination** the Witness Testified as Follows:

I say that there is physical distinction between the Belle Mina and Rodgersville properties and the distribution systems covered by the contract of August 9. The way they handle it is to bill individual customers in the small places, while they might take these towns and bill them as one unit. I have read the January 4 contract and sections of

the Carolina contract and of the Tennessee Public Service contract. I am not generally familiar with the commercial functions to be carried on by the Tennessee Valley Authority at the time of the filing of this suit. The contract of January 4 covers the counties indicated in color on defense Exhibit 97. It extends down to North Cullman. I do not know the number of direct customers in that area. I do know the load those customers will consume. I do not know the population within those seven counties, neither do I know the population and number of customers in the ten counties in northeast Mississippi. I can not give you the figures as to the counties in the State of Tennessee.

I did not mean to state that the same power or the same amount of power was delivered in Mississippi as was originally put on the power companies lines under the interchange agreement. The power is put on the lines, but we can't put a tag on it there. We can't tell just where it goes. It is measured at the interchange point. In practice, we get together with the power company at the end of the month when the power is computed. If the Tennessee Valley Authority has used more power in the Mississippi area than it has delivered at the bus bar, it pays the excess, and if it delivered more than it used, the power company pays for the excess delivered. The Blue Mountain distribution area is connected with a main transmission line. It was connected on February 11, and Hickory Flat, Blue Mountain and Myrtle are now connected with the transmission system. There are stand-by steam plants at Tupelo and at Corinth. They are retained by the Tennessee Valley Authority and held for stand-by purposes. The boilers are kept full of water in order to generate power in a hurry if there should be some interruption of service coming into that area. A line has been constructed from Wilson Dam to Wheeler Dam and a line is being built to Pickwick Dam.

The line to Wheeler Dam is designed for a 44KV line with a capacity of 397,500 KW. I don't know anything about the power policy of TVA.

Defense Exhibit No. 98 does not purport to show all of the towns in the area. The purpose is merely to show the municipal systems and the nature of the service. I am not talking about going out and getting customers, I am just showing you where these plants are. I do not think that these towns would be justified in building transmission lines to Wilson Dam. There has been a line built by Tennessee Valley Authority from Athens, Alabama to Pulaski, Tennessee. Tennessee Valley Authority also serves the City of Athens on this interchange agreement. The chief operating officer at Wilson Dam is Mr. Besserton, and Mr. Llewellyn Evans is the Chief Electrical Engineer. When I made the statement that it was necessary to have transmission lines to supply these dams, I did not mean to imply that the lines to accomplish that purpose are in any way related to the contract. I do not believe that a storage dam, such as Norris, will produce any firm power. There are certain seasons when you store water and certain seasons when you release water. I understand that the Tennessee Public Service contract expired on November 1, 1934.

In stating the figures as to power available at Wilson Dam during the past years, I was not speaking of power actually generated, but power that could have been generated with the present capacity and the actual water in the stream. I have also shown what was generated and what was sold. The voltage at which energy comes from the generator varies with the operating condition. It varies between 11,500 and 12,000 volts. Before it is transmitted it is put on the low tension generating bus. Some of the energy is used at one voltage, some stepped up and some

stepped down. The energy is sent to the government fertilizer plant at 12,000 volts over 110 KV line and is stepped up to 110 and then stepped down at the Steam Plant, and there distributed to the fertilizer plant. In stating the existing KW demand in the north Alabama area as being 15,074 KW, I did no include the north Mississippi area. The Pontotoc property was transferred to a set-up that is similar to what we have in Alcorn County. The Georgia Power Company, the Tennessee Electric Power Company and the Alabama Power Company are interconnected, and they connect straight on through with some of the other systems. During the last year we have used approximately 6,000,000 KWH at Wheeler Dam and approximately 13,000,000 KWH at Norris. That 13,000,000 includes the Town of Norris and the 6,000,000 at Wheeler includes service to the camp as well as the actual construction. It is obvious that if that amount of power was not used for those purposes we would have that much more available. I do not have those figures in terms of peak demand, and I wouldn't want to guess at it. I have not been called upon for the allocation for any specific KW capacity. I don't know about the plans of the Authority.

(At this point the following occurred: Mr. Fitts: The last witness is Mr. Falck. May it please the Court, I want to make one statement about this. The Court will recall that at the time that Major Whitman testified on this question of the market for power and surplus capacity, we objected to that line of testimony and had quite an extended argument. The Court seemed to be of the same opinion that we were, that it was probably irrelevant. But it being in the record and we not being able to be sure what this Court or some subsequent Court may finally say about it, we are going to put on some testimony on the subject, still maintaining that it is irrelevant and immaterial.)

EDWARD FALCK

Called as Witness on Behalf of Defendants Testified as Follows Upon **Direct Examination:**

My residence is Chattanooga, Tennessee, and I am an industrial engineer by profession. I graduated from Columbia University in 1930 with an A. B. degree; Bachelor of Science in 1931 and Master of Science in Industrial Engineering in 1932. During the interim period I made special studies of economics and statistics of public utilities. At the present time I am rate engineer for the Tennessee Valley Authority. I have made a complete study of generating capacity in the Tennessee Valley area and of the existing and potential demand for power in that area. The area which I finally selected is that covered by seven states, parts of which are in the Tennessee Valley basin. Those states are Alabama, Georgia, Kentucky, North Carolina, Mississippi, Tennessee and Virginia. The electric systems in that area are interconnected in such a way as to justify the treatment of the area as a unit. The power utilization per KW in the United States as a whole is in the neighborhood of 2,300 hours per year and in the Valley group it is about 2,000 hours per year. That ratio is the ratio of KWH per KW of rated capacity. I believe the difference arises from the fact that in this area the capacity is predominately hydro and due to stream flow fluctuations the ratio for hydro capacity, when added to the steam capacity used for stand-by purposes is less than it would be if the plants were operated on base load steam. It is not possible to consider supply separate from demand, because electricity is a service rather than a commodity and must be produced at the instant it is distributed or used. I did not consider all idle capacity as surplus capacity because there are various reasons which make a certain

amount of idle capacity necessary. The greatest factor is the various time changes in load. The second contributing factor is the seasonal variation in load. It is also necessary to anticipate the normal long term growth. The fourth factor is the fluctuation caused by boom and depression periods. All of these factors make it necessary for the installed capacity to exceed the amount which is demanded on the average. The chart which has previously been offered in evidence as defense Exhibit No. 1 was prepared by me. That chart was constructed by taking the actual production as covered by the United States Geological Survey for each of the seven states included in this study. Those items were added together and the average was taken. That was done for each of the 13 consecutive months and that average was struck. The heavy white line on the chart is indicative of this averaging process. A peak was reached some time during the latter part of 1929, and there followed a period of curtailment from 1929 to 1932. Subsequent to that time there ensued a period of recovery which is in a general upward direction. Production from the lowest point in 1932 as compared with the highest in 1929 was about 16% down. During the period from 1932 to 1934 the demand increased about 11%, and more than 50% of the loss during the curtailment period has already been recovered. If industrial load should return to the 1929 level, the total demand on the central stations on this area would be greater than in 1929, due to the fact that residential and commercial sales have increased despite the depression. Residential consumption per customer increased from about 420 KWH to more than 600 KWH during the five years. An 8% increase in the 1934 load would be sufficient to restore the load to the 1929 level. In computing the adequacy or inadequacy of existing capacity the demand which is likely to occur before

additional facilities can be installed should be considered rather than the existing demand. What we are concerned with in such a study is whether or not the existing capacity is capable of meeting the demand which might occur within the near future before additions to plant can be economically installed. I have secured from the published records of the United States Census the actual demand and capacity for about 35 years. In order to check that series of data the similar series prepared by the United States Geological Survey, dated from 1926 through 1934, was also used. There appeared from this data analysis a persistent and well defined correlation between production and time. In order to test that underlying relationship, I followed various methods which are familiar to statisticians. The relation appeared to be of a parabolic nature. It followed a curve which is well-known in the study of population. The experts of the United States census have for years used population growth curves for forecasting population growth. We have calculated the departures of the actual production figures from the growth curve. We tried curves of the exponential type which is something that grows in the way compound interest does. We also tried curves of the linear type, which grows in constant amounts every year, and we tried curves of the potential types and various others. For each group we tested the probable errors in several ways. Comparing years like 1927 to 1932 to the points which are indicated by the curve, we derive an approximation which so very well expresses the underlying order of the curves that we selected that as being representative. The chart entitled, "Past and Probable Future Trend of Electric Production, Valley Group" was prepared by me. That curve shows the result of this analysis. The curve marked "Trend" represents the underlying order between production and time and the small crosses indicate

the actual points which deviate to some extent from the trend. The curve is definitely upward. It indicates that it will continue to be upward. (At this point there was identified and offered in evidence the above mentioned chart as defense Exhibit No. 99, which is omitted in this narrative.) The actual production of electricity in 1934 was 7% under the point which is indicated on the curve as normal. For 1937 the indicated normal is 28% over the actual production in 1934. In order to reach that point in 1937, a growth at an average rate of 10% a year would be required during the next three years. As I recall, Major Whitman in his testimony made an estimate of growth between 10 and 12% per year. If the normal experience of the past continues until 1942 the production in that year would be 55% above the 1929 production and would be about 67% above the 1934 production. In determining the capacity which is available to meet the demand of the market it is necessary to discount the installed capacity by a certain amount because of certain factors. Among the factors which tend to freeze a portion of the capacity is the necessity for providing for break-downs of one sort or another. In addition there must be reserves for meeting cyclical rebounds in order to meet increases in business activity which may come at any time. There must be additional reserves for break-downs in transmission networks. At the distribution centers, there are steam reserves not used except in emergency. Then, there is a certain amount of hydro capacity which is frozen or sterilized by reason of the fluctuations in the stream. On the average, a figure of 40% for this frozen capacity is conservative.

For the purpose of this study I have assumed a load factor of 52%. The average of 16 Southern companies over a period of years in no case exceeded 52%.

Referring to the chart entitled "Plate VII B—Utilization

of Installed Capacity, Valley Group," for the year 1929, the theoretical maximum amount of output is 30.8% actually used. The shaded blocks first and second from the bottom of the chart indicate the amount of capacity which is unavailable for use. The surplus capacity is indicated by the small rectangle at the top of the column which in the year indicated, on an energy basis rather than a capacity basis, was less than 1%. In 1932 the available energy not in use increased to 8% and in 1934 due to the recovery in load declined to about 6%.. Plate VIIA shows the same condition over the period from 1927 to 1933, and Plate VII shows the same situation from 1902 to 1932. Those charts were prepared by me. (At this point the charts referred to by the witness were identified and offered in evidence together as defense Exhibit No. 100, which is omitted in this narrative.)

In the computation, I have made no deduction for obsolete generating equipment. It is generally known that there are obsolete plants in this area. In 1934, for this area the total capacity which could be called effective and available for use was 2,020,000 KW while the peak demand was 1,579,000 KW, indicating in that year a surplus of 17%. It would require about two years normal growth at 8%, or three years sub-normal growth at 6% for the peak demand to increase to a point where it would be equal to the effective capacity. If the 1929 industrial load had prevailed in 1934 the surplus capacity would have been about 10%. If my normal prediction holds true there would be no surplus in 1937. In fact, there would be a shortage amounting to about 7% of the effective demand. According to the normal prediction in 1942 there would be a shortage of about 40%. If the load did not recover from the depression but grew at its normal rate, starting from the low point in 1932 instead of from

the high point in 1929, the shortage in 1942 would be only 22%.

The chart entitled "Plate IX" was prepared by me. It shows the relation of power resources to power requirements in this area. The shaded space shows the surplus. You will note that in 1926 through 1929, there was some surplus, but not material. After 1930, with a decided drop in demand caused by the depression, the surplus increased to a maximum in 1932. After that date, the surplus began to diminish. The demand growth from 1934 is projected in accordance with the assumption that the normal experience as shown by the curve previously submitted continues. That indicates that the surplus will disappear in 1936 or 1937, and that after that date a material shortage of power would exist unless additional capacity is added. (At this point the chart referred to by the witness was identified and offered in evidence as defense Exhibit No. 101, which is omitted in this narrative.) At the present time there is some surplus in the Valley group, but it is not of great consequence in view of the restriction of existing demand.

The area selected by Major Whitman was not identical with the area which I selected. His exhibit and testimony included quite a number of plants which appear to be obsolete. He included the Birmingham Electric Company apparatus of 5,000 KW. This plant was constructed in 1901 and has not been operated since 1927. Major Whitman made a very conservative estimate on prime capacity as though no allowance for break-down or for emergencies or repairs was required. No provision was made for growth, and Major Whitman based his estimates upon 1933 which was subnormal year. The use of 1933 data under-estimates demand and over states surplus. Major Whitman states his surplus in terms of

demand. Upon that basis the surplus was equal to 60% of demand. Most engineers express surplus as a capacity ratio. If you approach it in this manner Major Whitman's 60%, through a matter of arithmetic merely, reduces to 37½%. Major Whitman included a large number of steam plants which are far beyond the confines of the Tennessee Valley region, this increases the apparent available capacity. Taking that 37½% of capacity on Major Whitman's basis and allowing 10% for growth, and allowing another 10% for reserves and stream flow fluctuations, that percentage would be reduced to 17½%. If you then take the difference between 1934 and 1933, it would further be reduced to 7½%.

Upon **Cross Examination** the Witness Testified as Follows:

The amount of total capacity is derived from the total installed capacity. There has been practically no change in the total installation in this area over these years. I froze out 40% of capacity in both 1932 and 1934. I have estimated that as a representative measure of the amount of capacity which is to be reserved for break-down, emergency, and growth. That reserve was derived in several ways. Perhaps the most realistic way is by taking the actual relationship between peak loads and the rated capacity of well managed utilities. That ratio for this group has never exceeded 60%. I have taken the result which that management has secured and considered that as representative of what may be secured in the future. Surplus as I have used it is that which is not required; that which remains over after all wants and needs have been met. It may be that there is some capacity which is not used all the time or which may

never be required, but its existence is necessary on account of the exigencies of the electric industry. I do not consider that surplus. There was in 1934 a substantial excess in capacity. I have considered the entire network as interconnecting. All capacity units in excess of 100 KW are included. Where the network extends beyond the area I have gone outside and that results in over stating the surplus. If effect were given to the fact that fully 100% interconnection has not yet been obtained, the available surplus would be correspondingly affected. I have given consideration to all plans, the energy produced by which is devoted to public use. The figures are taken from the reports of the United States Geological Survey for the years from 1926 through 1934. The interchanging in power outside of the area is negligible. There was some industrial pickup in the early part of 1933. From about the middle of 1933, the average line has about flattened out. The utilization depends upon a number of factors. If it were true that the low use in the Tennessee Valley region was caused by an existing surplus capacity then the utilization of the country as a whole would be less than for the Southern states, whereas the contrary is true. That low ratio could be caused by over production. In my original computation, I took the seven states, parts of which are in the Tennessee Valley. I also made a computation with substantially the same results excluding Virginia, Kentucky and South Carolina. I do not agree that most of the State of Virginia is far beyond transmission distance.

In Plate VIIB that 68.8% is not of the total capacity, but of the theoretical maximum energy which could be derived if the installed capacity demand at its rated KW were multiplied by 8,760 hours per year. My statement as to what was included was based upon professional

papers issued by the United States Geological Survey and explanations in the text which stated that the Report included all establishments having a capacity of at least 100 KW. which generated electricity for public use, and in addition to the central stations and railways, included electric and steam railroads, public works, manufacturing establishments and federal government plants which supply energy for public consumption. The capacity is separated as between fuel capacity and hydro capacity, as to totals by states. There is no separation as to companies as between hydro and steam. The 40% deduction was taken as representative of the general situation in the Valley area. Undoubtedly what Mr. Bowman's testimony covered, in his statement that there would be 315,000 KW of installed capacity as against 280,000 KW prime at 55% load factor, was the physical or technical capacity. What I consider is the economic capacity which is much less than the technical capacity.

I am basing my judgment on the experience of the industry. I stated that I was for a time employed by the Chatham-Phoenix Bank. In the summer of 1933 I was employed by the J. G. White Corporation, making a valuation of some of the properties of the Sheffield Farms Inc. That is a milk and cheese company. I was appointed to employment by the Tennessee Valley Authority at the time when I was engaged in this work. I am head of the Division of Rates, Economics and Research. I have had no actual operating experience in connection with the operation of a plant containing steam and hydro units. I did not have the systems in making this study. I took totals from the United States Geological Survey. The allocation for any particular system will vary. The 40% deduction varies as between an all steam plant, a composite run of the river hydro and steam plant

and an all hydro plant. It would vary for a particular system, but for a region it probably would not. I have made studies of the Long Island Lighting Company in New York in 1930, 1931 and 1932 in association with Robert T. Livingston, their chief research man. That was before my graduation. Surplus capacity is related to the availability of energy as well as to demand. Ordinarily, the limiting factor is the maximum rate of demand, but in either a hydro or a steam plant the actual amount of energy must also be available. Interconnection of several power systems increases the total effective capacity. The method of arriving at the original gross capacities was to take the existing capacity and add them together, and then take the KWH and add them together and arrive at a conventionalized peak. The conventionalized peak was not the summation of the actual peaks which undoubtedly would have been greater. Had interconnection been ignored, the load factor of the isolated plants running around 40% would have been used, which would have given a resulting conventionalized peak much larger than that assumed, and would have resulted in a smaller surplus. My information is that in the isolated plants the load factor varies from 40 to 42%. I obtained that data from the annual Supplement to the "Electrical World." For municipal load factors, I obtained the information from the files of the Tennessee Valley Authority. The towns that the Authority is serving are typical of municipal service in this area. The load factor of 52% exceeds the average of all of the well integrated systems of the area. According to the annual Supplement to the "Electrical World," the indicated load factor for 1929 for the Alabama Power Company was 52%; for 1931, 52.7%; for 1933, 46.8%; for the Georgia Power Company in 1929, 50.9%; 1931,

55.8%; 1933, 50.2%; for the Mississippi Power Company in 1929 44%; 1931, 51.5%; 1933, 50.6%; I do not have the load factor for the system as a whole. The installed capacity in 1934 was 3,370,000 KW. I found that 2,020,000 KW was effective and available. I believe that what I said was that the discounts which Major Whitman used for low flow conditions in the hydro plants seemed to me unduly conservative. My study of the total load included residential, commercial and industrial as well as municipal uses.

Upon **Redirect Examination** the Witness Testified as Follows:

In a very general way I am familiar with the properties in North Alabama covered by the contract of January 4, and I am familiar with the properties in Northeast Mississippi. I am familiar with the nature of the small properties at Belle Mina and the so-called distribution system at Athens covered by supplemental agreements mentioned in the testimony of Mr. Barry, and also with the properties at Ardmore and Rodgersville. There is a material difference between those properties and the urban distribution systems in that area. The properties such as Ardmore and Belle Mina cover a territory with a relatively light density. The type of service, that is rural supply lines with one transformer and the straggling nature of the operation, is such as to classify it functionally and economically as rural. Whereas, in Decatur or Florence there is a large enough system to permit economical and technical specialization of function, and those latter systems would be classified as urban distribution. Plans to connect Blue Mountain and Myrtle to the main transmission line in Mississippi were made immediately after the acquisition of those properties. I

think the construction started in November or December. Referring to defense Exhibit No. 97, the figures as to load include the actual existing demand in all of the communities that are served from the transmission lines in suit.

Upon **Recross Examination** the Witness Testified as Follows:

Referring to the Rodgersville and Belle Mina properties, my information is that about one customer per transformer is typical along those lines. I have not made any study of the number of transformers per customer. I do not know the number of customers in those areas. I mean the service there is different from service to an urban area. The difference between urban and rural is a matter of degree. I say there is a real distinction between those systems and an urban system. Most of the customers are served directly from 11 KV lines. Eleven and 13 KV lines are typical rural supply lines; whereas, in the ordinary urban area, the secondary circuit will run to 2,300 volts. The systems there as shown on the map are 11 KV lines. I am stating this from observation. I have made no examination as to what break-down in voltage is employed in those areas. Where service is direct by the Tennessee Valley Authority, I think that the bills are made up in Chattanooga. Whether they are sent from there or locally distributed, I don't know. At the time of the filing of this suit the contracts outstanding for the purchase of properties by the Authority were the two Alabama Power Company contracts of January 4 and August 9, and the contract with the Tennessee Public Service Company. There was a contract for the sale of properties in Alcorn County by the Authority to the Alcorn County Electric Association, which is a cooperative. I think it is misleading to

say that the Tennessee Valley Authority created the Alcorn County Association. That is a corporation created under the laws of the State of Mississippi upon application of rural residents of Alcorn County. The organization of cooperatives is one of the methods being employed by the Authority in handling the distribution problem. I think that it is probably true that there would be more than 25,000 people buying electricity in Knoxville and its environs. I think there were five counties in Tennessee which were to be temporarily served by the Authority under the contract with the Tennessee Public Service Company. I do not remember the exact number of direct customers in the area served by the Tennessee Electric Power Company system which was to be conveyed to the Authority under the contract of January 4. In the Mississippi territory, I think that there are around 4,000 customers, but I would have to look that up.

Upon **Redirect Examination** the Witness Testified as Follows:

So far as I know, the Tennessee Public Service Company contract is dead.

Upon **Recross Examination** the Witness Testified as Follows:

I am familiar with the fact that that contract is not now in existence. I do not know anything about the status of negotiations or the plan of the Tennessee Valley Authority.

At this point there was offered in evidence a certified copy of an excerpt from the minutes of a meeting of the Board of Directors of the Tennessee Valley Authority held January 3, 1935, which was identified as defense Exhibit No. 102 and read as follows: "The board authorized Assistant Chief Engineer Carl Bock to cooperate with the

Chattanooga Protection District in the preparation of flood control plans and to provide engineering consultation and advice to the engineering staff of that organization."

At this point the following occurred:

"Mr. Fitts: Now Mr. Johnston has placed in the record certain schedules relating to the cement contracts. The purpose of his evidence was quite obviously to show a definite plan for the construction of certain dams. We, therefore, feel it proper and relevant to put into the record the contract itself, but it is unnecessary to put in all of the contracts or the entire contract. I have checked this over with Mr. Johnston, and we have agreed that there are only two portions of the contract that bear any relation, so we will offer merely the first paragraph, which is "Scope of the Contract," which shows exactly what dams it relates to, and the fourth paragraph, which relates to "Commencement, Completion or Delivery." The contract is Tennessee Valley Authority—"Contract for Type B Portland Cement"—Hermitage Portland Cement Company. We offer those two portions of the contract as defense Exhibit No. 103 as being typical of all of the other cement contracts."

Whereupon the portions of the contract were received in evidence as defense Exhibit No. 103. The substance of such exhibit is as follows:

"1. Scope of Contract.—The Contractor shall manufacture, sell and deliver bulk Type B Portland Cement for Norris Dam, and Wheeler Dam, in strict accordance with attached specifications and at such other points and in such quantities as are set out in the schedules attached."

* * * * * * *

"4. Commencement, Completion, or Delivery.—De-

liveries shall be made in bulk in carload or barge lots. The Contractor shall be prepared to submit bins for test within 15 calendar days from receipt of written notice of award of this contract or at such earlier date as the Contractor may have specified in his bid. Before making the first, or any subsequent delivery, the Contractor shall have and maintain on hand an adequate supply of cement to enable inspection and complete tests to be made as set out in the specifications.

"Deliveries shall be made in such quantities as shall be requested by the Authority from day to day, and the Contractor shall, if required, maintain deliveries at a combined estimated maximum rate of four thousand (4,000) barrels per day and a combined estimated maximum rate of eighty-five thousand (85,000) barrels per month for Norris Dam and other upriver dam projects, and a combined estimated maximum rate of three thousand (3,000) barrels per day and a combined estimated maximum rate of sixty-five thousand (65,000) barrels per month for Wheeler Dam and other downriver dam projects. The Authority reserves the right to increase or decrease the total quantities covered by this contract as shown on the schedules by not to exceed twenty per cent (20%); **provided,** that such increase or decrease may be made in the total quantities under any contract at any time before total shipments have been completed.

"Shipments shall be made on Government Bills of Lading if the Authority shall so elect. Risk of loss, damage, or deterioration of all shipments of cement from any and all causes shall be borne by the Contractor while the cement is in transit and until such time as the cement is delivered at the specified point of destination and accepted by the Authority, **provided,** that cement shipped on Government Bills of Lading, at the request of the Authority, shall be at the risk of Authority (except as to loss due to improper prepa-

ration of cars) while in transit to the railhead specified in such bill. In the event shipments are made on Government Bills of Lading, the Contractor shall prepare the railroad cars in which shipment is to be made in such a manner as to prevent loss, damage or deterioration due to improper preparation of the railroad cars. The cost of preparation of the railroad cars shall be included in the unit price bid in the schedule."

PERCY H. THOMAS,

Called as Witness on Behalf of Defendants, Testified as Follows:

I reside in Washington, D. C., and am an electrical engineer by profession in the employ of the Federal Power Commission on the staff of the National Power Survey at the present time. I graduated from the Massachusetts Institute of Technology in 1893 with a degree of Bachelor of Science. For the first ten years, I was with the Westinghouse Electric Manufacturing Company specializing in power matters. Then I became Chief Electrician of the Cooper-Hewitt Electric Company. Then I was in practice for nine years as a consulting engineer, and after that for several years with the firm of Guggenheim Brothers in charge of their electric power business. I was connected with the American Institute of Electrical Engineering and the representative on the Joint Committee on Overhead and Underground Construction; that being the Committee which drew up the original specifications for crossing of power lines over telephone and other communication circuits. I acted as consultant to William S. Murray in connection with the Super-Power Survey covering the region from Boston to Washington, D. C. I acted as consultant to Mr. Frederick Darlington, Chief of the power section of the War Industries Board during the war. I am a Fellow of

the American Institute of Electrical Engineering, and I am a member of the American Society of Mechanical Engineers. (At this point the following occurred:

"Mr. Fly: Your Honor, again we want to treat briefly of that subject which we think is irrelevant, but which is covered by the plaintiffs' case dealing with the possible surplus. Of course, this is submitted on the same understanding upon which Mr. Falck's testimony was submitted.")

I have made a study of the power situation in the general area of the Tennessee Valley. The Federal Power Commission has given me the privilege of consulting the records which they have collected from the industries in connection with the National Power Survey, which they are making upon order of the President. I have found that in 1937 there would be a shortage of power in this region in the neighborhood of Wilson Dam and the states adjoining. In connection with the preparation of this National Power Survey the Federal Power Commission sent questionnaires to all of the utilities in this country and returns have been received from very nearly all of these questionnaires. From the data given in these replies, that is, the figures furnished by the utilities themselves, I have been able to determine the relation of supply and demand for the year 1937. I went over the returns from the individual utilities which furnished the necessary data as to dependable capacity and power loads, made a summation of both, made an allowance for diversity and reserves and took the difference to indicate the power shortage or surplus. In that study I included the territory served by all of the systems forming a part of that large network of transmission lines adjacent to and interconnected with the power plant at Wilson Dam. I have excluded systems

which were not so interconnected. The total dependable capacity in that area upon that basis is 2,272,000 KW. The peak load after allowing for 7% diversity was 1,965,000 KW. I made an allowance for reserves for all purposes of 615,000 KW. The available dependable capacity which is required for such a peak load is 2,580,000 KW, leaving a shortage of 308,000 KW for the year 1937. The available dependable capacity includes only those units which are interconnected in such a way that they can give and take power. Dependable capacity is that which can be entirely relied upon in a dry year on the peak of the market demand for that year. It does not include what I have considered to be obsolete or void installed capacity. If the output of a station is limited by the boiler capacity, I have used only that amount of power that can be obtained from the boilers. Where the output of a steam station may be limited by contingencies of water or temperature, I have considered the total that may be dependably taken from that apparatus. In the case of hydro plants, I have taken the dependable capacity of low water as given by the companies. I have considered the year 1937, because, with the exception of the Tennessee Valley Authority program, there is no construction of generating facilities taking place in this region at this time. I have considered as obsolete steam equipment, steam or internal combustion machines which would not be counted upon by a system planner in making his arrangements for meeting the peak of the year 1937. Under peak load, I have taken the forecast of the reporting companies for the year 1937 so far as they were available. In the few cases where forecastings were not given, I have increased the 1933 peak loads in the same ratio that is actually shown in the forecasted returns. In the case of the Aluminum Company, I have used for 1937, the maximum peak demand reported for prior years, assuming no

increase over past demand. In the case of the Birmingham Electric Company, I took the highest available previous peak demand. Those peak demands were added up, and 7% deducted to give the peak for use in determining the peak shortage. For reserves, I assumed that six of the largest size generating units in the area might be out of use. Those include both steam and hydro. I have allowed for failure of generating machines 10% of the required dependable capacity. The shortage is approximately 15% of the required dependable capacity. The relation of this installed capacity to the peak load is very close to that which Mr. Falck used in his testimony. The documents entitled, "Report on Electric Power and Electric Rates" and "Report on Electric Power and Rate Survey" are two of several questionnaires that were sent out. They are the questionnaires which were used by the Power Commission. The document entitled, "Report of Electric Power Survey, Form II," is the questionnaire sent out to all the major utilities. It is from the returns on those forms that I obtained a very large portion of the data used. (At this point the above mentioned documents were offered in evidence as defense Exhibits No. 104, No. 105 and No. 106 respectively. These Exhibits are omitted from this narrative.)

I am familiar with the problem of the supply of electric power during the World War. As consultant to Frederick Darlington of the Power Section of the War Industries Board, I became familiar with the problems that arose in supplying adequate electric power for operating industries. There developed an acute shortage of such power. In the fall of 1917, there was an acute shortage in those industries where war materials were being produced. Every war material requires the use of electric power. It became very difficult to keep the war industries going. When the armis-

tice occurred, it was evident that if the war had continued for a year or two more in all probability the lack of facilities would have been a serious limiting factor to the conduct of the war. It is impracticable to supply any considerable quantity of new electric generating equipment without considerable time for its design, manufacture and installation. Starting with 1917, power was requisitioned and alloted to specific industries. It was necessary in one area, at any rate, Western Pennsylvania and Ohio, to exhibit the placing of further orders for a while on account of lack of power. The War Industries Board established the Power Section with authority to administer the use of power. Despite the fact that there was a great shortage in coal certain amounts of it were allotted to steam generating plants, power being more important even than the coal. In 1918, a bill was prepared authorizing the Federal government to build, lease, operate and take over power systems. That bill passed the House, but the armistice came before it reached the Senate. The power shortage developed first in the region where there was a large electro-chemical industry. It occurred in New England, in Eastern Pennsylvania and New Jersey, in Northwestern Pennsylvania and Ohio, in the Southern states and on the Pacific coast. There was a shortage in the Southeastern states. Every effort was made to take power from those places where it was plentiful, as in Alabama, over into neighboring states, where the supply was not as great. It was recognized that the water power at Muscle Shoals offered a very large amount of energy, but in view of the low river flow in dry seasons, it was necessary to provide steam reserves and store water. The plant on the Tallapoosa River with large storage facilities, rather close in character and capacity to the present Norris plant, was recommended as well as transmission lines to connect this

into the existing network. In the case of a war of the first magnitude, I do not see how there can be any doubt that the demand for war materials will be practically unlimited. None of those can be produced without a large supply of electric power. Since it takes some years to make the necessary installations unless some provision is made before hand the supply of power is almost certain to be a serious limiting factor in the production of materials. In order to make Wilson Dam more useful for the purposes of the national defense, it is necessary to secure a dependable capacity to fill in the periods of low stream flow. The storage of water is one very important method, and the interconnection with the great network of transmission lines within transmission distance is essential. The Wilson Dam has this great advantage; it lies at an intermediate point in a very important industrial area and as the demand for power may be excessive in one part of that area or another, the power can be diverted to such point. There is a distinct advantage in hydro installation for the supply of electric power in war time since it requires no coal, and a very small operating staff. At such a time, the production of coal is inadequate and the railroads are overburdened with freight. The installation of generating equipment or emplacements in dams constructed as a part of a navigation and flood control program in the Tennessee Valley would be valuable from the standpoint of the national defense. The emplacements are valuable for the reason that electrical generating equipment, which may be in the process of manufacture at the time of the emergency, may be transferred to those emplacements. It is even possible to take existing machines from their emplacements in areas where the demand for war material is not great and put them on emplacements where power is in extra demand.

I am familiar with a book entitled, "The Power Situation During the War" by Colonel Charles Keller of the Corps of Engineers. Colonel Keller is a recognized authority in this field. The book is a standard authority.

At this point extracts from the book above referred to were identified by the witness and read. The substance of these extracts is as follows: Beginning on page 1. One of the great difficulties encountered during the war was that created by the exhaustion of central station electric power in the principal manufacturing communities. A large and important center of electro-chemical, electrolytic and electric furnaces were grouped in and around Niagara Falls, New York. These industries were all of vital consequence to the success of the war. There was a definite power shortage in that area.

The first paragraph on page 8, in substance is as follows: It was realized that for any prolonged war, it would be necessary to relieve as much as possible the strain upon our coal supply by the further development of water power at Niagara.

The second paragraph on page 9, is as follows: The reason for describing the situation at and near Niagara Falls and the remedies attached is that here were developed the various steps necessary to be taken in the handling of similar difficulties elsewhere. Plans should be prepared for increasing the power supply so as to best meet the needs, such as contemplating first, the installation of the additional capacity to meet the immediate needs of the emergency, and next, the installation of such further capacity as is deemed necessary to meet the more slowly expanding requirements of a modern war of several years duration.

At this point the following occurred:

"Mr. Fly: A book by Grosvenor B. Clarkson entitled, "Industrial America in the World War" has heretofore been duly qualified and I will ask the reporter at this point to copy pages 459 to the middle of 463 as marked." The extract in substance is as follows: Chapter 29, "Power and Transportation as Fighting Factors." In war all things depend upon power and transportation. The War Industries Board encountered the power feature problem at every turn. The shortage of electrical power in some of the congested centers such as Pittsburgh, Buffalo, and Niagara Falls and a number of places in the South became alarming in the fall of 1917, and it became necessary to apply the priority principle very strictly, rationing and even withdrawing all power from some non-war industries. As private development under war conditions of a degree of power that might not be needed for some time under normal conditions was out of the question, it was necessary for the government to undertake the work. Despite all that could be done, the power shortage in the Pittsburgh district in 1918 was not less than 130,000 KW. Besides the reinforcement and supplementing of existing power service plants there were large problems of furnishing power for the government explosive plants at Nitro, Nashville, and the nitrate plants in Alabama.

The Testimony of the Witness Upon **Direct Examination** Continues as Follows:

There is a large amount of interstate transmission of electricity in the area comprising the states of Tennessee, Alabama, Mississippi and Georgia.

Upon **Cross Examination** the Witness Testified as Follows:

I am on the staff of the Federal Power Commission. I have been permitted to take the time to make this study and this report as an engineer in my personal capacity. Quite recently, less than three weeks ago, I was advised of the request for my services in this case.

In dealing with dependable capacity, I accepted the capacities as reported by the companies, except where I considered the capacity obsolete. Everything is based on the figures that the companies gave directly or indirectly. The figures supplied by the companies did not give information as to dump power. I did not discount the figures given by the companies, but I laid aside certain plants as not suitable for reliance by a system planner whether the companies reported them as reliable or not. As a matter of principle I studied one by one the plants of under 200 KW capacity to see whether or not they should be laid aside. I excluded all systems that are not at present interconnected. I did exclude the stand-by plant of the Birmingham Electric Company as it was not reported as operating. The set-up, so far as Tennessee Valley Authority is concerned, is based upon the assumption that the Sheffield Steam Plant is connected with a dependable capacity of 60,000 KW; that the Wilson Dam plant is connected with dependable capacity of 50,000 KW; and that the Tennessee Valley Authority has no load in 1933 or 1937. The Tennessee Valley Authority did make a return to the questionnaire. I do not remember that any load was forecast. They indicate on their report Wilson Dam, Norris and Wheeler. That was an informal return. I do not remember just what the load figures were, and I have assumed no load in my studies. I have not considered Norris. I do

not know what the Tennessee Valley Authority program is, and I do not know what their loads are. I have included in this study the Virginia Public Service Company, the Virginia Electric Power Company and two or three small companies in Virginia; in the Carolinas, the Duke Power Company and the Carolina Power and Light Company; the Georgia Power Company and some small companies in Georgia; the Alabama Power Company; the Tennessee Power Company; the Tennessee Public Service Company and others in that area. I did not include the Appalachian Electric Power Company because it is a part of a large, well interconnected network to the north not running in synchronized regularity to this large network to the south. They do interchange some power, but not firm peak power so far as I am informed. I did not consider that that system was interconnected in the sense in which I have used the term. The Tennessee Coal, Iron and Railroad Company's 25,000 or 30,000 KW unit in Birmingham was not considered. The total capacity reported by the six units that I deducted was 308,000 KW, including the Sheffield Steam Plant as one. That is around 13% of the installed dependable capacity. In addition to that I made a further 10% deduction which is a judgment estimate for other reserves. As one of the factors of reserve, I have added 2½% to the power to take care of business cycle variations. I have made no estimate of peak load for 1934. The sum of the peak loads as reported in 1933 without the diversity was 1,624,000 KW; for 1937, 2,098,000 KW. Dependable capacity for hydro for a dry year is considerably different from installed capacity. The 3,352,000 KW is the installed capacity of hydro units. Reduced to a prime capacity basis, the hydro is 1,252,000 KW and the steam installed is 1,176,000 KW. The questionnaires were sent out around the first of October, 1935. The installed

steam capacity of 1,176,000 KW includes the part that I have considered obsolete and void, deducting that amount the available installed steam capacity is 1,020,000 KW. For reserves, I adopted the practice of eliminating six of the largest units. I eliminated one of the Gorgas units of 60,000 KW capacity in Alabama. I eliminated the Atkinson unit in Atlanta, and in Tennessee I took the Sheffield Steam unit. I am not including any of the industrial units unless I have reason to believe that they are dependable capacity that can be called upon at the peak, and that the utilities relying upon them can have sufficient control of the personnel so that they feel that they can be depended upon. I have included two Aluminum Company plants, but other industries, even though they have considerable amount of capacity have not been included because I have no reason to believe that the utilities can call upon them against the interest of the industry. The Birmingham Electric Company peak in 1933 was 37,633 KW, and I took for 1937 peak, 55,800 KW, which was the peak reported for 1929. For that particular company that seems a fair assumption—that at some time they may return to that peak. That percentage, between 37,600 and 55,800 is a 67% increase. That represents a return to the load of 1929. That is not a forecast, but is a peak previously reported. I did say that the degree of interconnection that has been worked out in the Southeast is desirable. I did not say that that is all that might be desirable in the way of interconnection. The principal systems are interconnected. I do not include anything that does not have a reasonable back-up connection. The most desirable system of interconnection has an element of pooling of power in it, which certainly requires assistance and cooperation. The existing systems certainly should be included in any planning for war service. In looking forward to war conditions,

facilities should be made as voluminous as possible and the interconnection should be as complete as possible, looking to the concentration of power in the areas where war materials are likely to be produced. The margin in excess of ordinary peace time reserve ought to be as large as possible. I would say that the program of the Tennessee Valley Authority being unknown according to the terms of the question, I wouldn't see how I can have any opinion as to its effect.

If this program is to improve generating facilities, that is helpful; if it is to the contrary it is not helpful. I think you must look at the net result with the point in view of the ability to generate and concentrate power. The problem with respect to competition and taking of the market from other utilities would be largely irrelevant in the national defense. The statement appearing in the professional paper prepared by me under the title of "Advantages and Economies," which is as follows:

> "All the advantages of diversity as applying to any interconnection are obtained, such as daily load curve diversity, reduction of spare capacity, divergence between the differing periods of activity of different activities where seasonal or due to swing of boom times and hard times, railroad electrification, etc., also diversity due to difference in the dry periods of water power at different parts of the district. While it is beyond the scope of this paper to study this particular matter in a numeral sense, it may be pointed out that with a diversity gain of 10% on the total peak output, here taken as 1,250,000 KW on the 100 KV lines, the additional power that might be sold would be 125,000 KW with no additions to the general installation,"

is a correct statement of my views. I don't think that there is data enough to state whether or not such result is

to be anticipated from interconnection if one of the constituents in the interconnection proposes to use it for the purpose of encroaching upon the proprietary markets of the interconnecting constituents. That depends on how they actually operate. The question of motive is not material. Any uncertainty in a situation, while it lasts is, of course, a disadvantage to any people involved in the uncertainty. The dependable capacities in an interconnecting system are the numerical sums of all the individual units. The amount of reserve required will vary depending upon the amount of interconnection, whether it is under one management or under friendly management or in some other situation.

GEORGE W. KABLE,

Called as a Witness on Behalf of the Defendants, Testified as Follows:

I am a graduate in civil engineering with the degree of Bachelor of Science from the University of California, Master of Science degree in agricultural engineering from the University of Nebraska. For three years I was agricultural engineer for the Oregon Agricultural Experiment Station in charge of rural electrification and research. I was then director of the National Rural Electrification Project. I was director of research for the Committee on the Relation of Electricity to Agriculture. During the past two years I have had temporary assignments with the Department of Agriculture in charge of a national survey of rural electrification under the Civil Works Administration. Since last July, I have been chief of the section of the Industry Division in charge of rural electrification research of the Tennessee Valley Authority. I have supervision of experimental work and research in the use of electricity on

farms. I have investigated the status of rural electrification in the area of the Tennessee Valley and in the North Alabama area specifically. According to the figures of the United States census for 1930, about 3% of the farms in the Tennessee Valley were served by central stations. According to those same figures, 10.3% of all farms in the United States were served by central stations.

The Tennessee Valley Authority has started the construction of rural distribution lines in the North Alabama area. There are approximately 68 miles of rural lines in the Western half of Lauderdale County, as shown by the green lines on defense Exhibit 97. There are about 18½ miles in Colbert County, as shown by the green lines extending south from Wilson Dam. Those lines have been in service for less than 90 days. All of that territory is close to Wilson Dam, and prior to the time those lines were constructed was entirely without service. In that territory there are a number of cross-road settlements with as many as 50 residences within a radius of a mile, and with schools, churches and stores. Some of them have grist mills and cotton gins as well. St. Florian is a typical community which is within approximately three miles of Wilson Dam, and has approximately 50 homes, a cotton gin, a grist mill, churches, schools and stores. There were also a number of homes within a radius of 2,000 feet of the dam which did not have any electric service. I know of no other way to dispose of surplus power generated at Wilson Dam to farm and rural communities not receiving service except by building or acquiring transmission lines. The statement appearing under the heading "Rural Electrification," beginning on page 51 of the report of the Mississippi Valley Committee of the Public Works Administration, which is as follows:

"Of the 6,000,000 farms in the United States, over

800,000 are electrified but only about 650,000 have high line service. The balance have individual plants expensive to operate and limited as to use. Over 5,000,000 farms are entirely without electric service. Estimates as to the number of these which can now be economically given service range from 1,000,000 to 3,000,000. The wide open character of this opportunity is emphasized by the much larger percentage of farms having telephones and automobiles than those having electricity, as shown on the accompanying graph.

"Unless the United States Government assumes an active leadership, assisted in particular instances by state and local agencies, only a negligible part of this task can be accomplished within a reasonable time.

"The big problem in rural electrification is not the cost of generating energy but the cost of delivering it to the rural customer. In Canada, Great Britain, France and other countries this fact has been recognized. . . . Several reasons might be advanced to explain why only 10% of the nation's farms (less than 6% in the Mississippi Valley) purchase electricity. These are the lack of interest by operating companies in rural electrification, the high cost of line construction because of the unnecessarily expensive type of line used, onerous restrictions covering rural line extensions and high rates,"

expresses my opinion as to the matters discussed therein.

Upon **Cross-Examination** the Witness Testified as Follows:

These communities in close proximity to Wilson Dam not now receiving electric service can in my opinion be served only by the construction or acquisition of transmission lines. It is true that rural service has been extended where rates are low in general. Throughout the Tennessee Valley area approximately 39% of the farmers are tenants. I do not

have the exact figures as to the net cash revenue obtained by each farm in the area. That does have a bearing upon whether rural service can justify itself in terms of economic return upon investment. As a rule the rural customers are rarely more than four or five to the mile. There has been a survey recently by the Tennessee Emergency Relief Administration which shows that there are something over 19,000 miles of rural highways along which there are five or more potential customers per mile which are now unserved. Some farms are now being served directly by the Tennessee Valley Authority over the lines that I have mentioned. What the Tennessee Valley Authority proposes to do in that regard is a matter of policy as to which I cannot testify. That includes not only the farm but the gin and the church and any one else that might desire electricity. It is very similar to service rendered by a public utility. The Alabama Power Company does have some rural lines and some transmission lines in the same general area. I know of no specific instances of applications from that area to the Alabama Power Company for extensions of service, but I know of a number of cases where farmers of that region have petitioned the Tennessee Valley Authority for service.

My duties are with reference to research, not line construction. My studies have not included the potential demand in the area. My work relates to the application of energy on the farms, rather than to the extension of lines. It is more technical in character than commercial. I do not know whether Tennessee Valley Authority has announced rules or conditions which if complied with would entitle any given area to extension of service. The research work relates to the adaptation of pumps and other electric farm machinery to the economics of the area. We are endeavoring to interpret the needs of the farmer and assist him to obtain the kind of equipment that will best

serve his needs, so that he will be able to use electricity advantageously and properly. I think there is no prescribed load of the number of customers per mile that applies to the entire Tennessee Valley. During the past seven months we have been working on types of pumps most suitable for this area, refrigeration systems, cooking units, electric water heaters, the development of an electrically operated sorghum mill and a number of other projects such as churns, heating and the brooding and incubation of chicks. Climatic conditions have a great deal to do with the type of equipment required. We are studying existing equipment and making designs where the existing equipment is not satisfactory. The area as to which I gave the percentages includes all of the counties which are 50% or more within the watershed of the Tennessee River. That does include a great deal of mountain land. A great many of those farms are more or less inaccessible to transmission lines as they now exist. I do not have the figures as to density of population or the number of farms per mile in the area. I was not aware that the City of Muscle Shoals had refused to permit the Alabama Power Company to extend its lines through it to serve those homes that I mentioned within 2,000 feet of the dam. There is no specific answer to the question as to how many customers per mile are required for self-sustaining rural electrical service. That is not a matter of the number of customers, but it is a matter of the power consumed. Some customers would consume many times as much as others. The Tennessee Valley Authority built most of the lines to which I have referred. I believe the Civil Works Administration contributed to some of them. I do not know the comparison between the farm income in this area as compared with the United States as a whole. The average size of farms in this area is 73 acres, and I know that in the territory north of here the average is larger. The size

of the farms has very little relation to the amount of electricity consumed.

Upon **Redirect Examination** the Witness Testified as Follows:

The consent or non-consent of the City of Muscle Shoals could not have anything to do with the lack of service in these areas in Colbert and Lauderdale Counties that I have mentioned. I do know of my own knowledge that the lines that I have pointed out have been built and that they are rural distribution lines serving rural customers.

PERCY H. THOMAS,

Being Recalled by the Plaintiffs Testified Upon **Recross-examination** as Follows:

I have worked out the dependable capacity referable to the Commonwealth & Southern units. I show for the five component companies in the Commonwealth and Southern system a total of 311,000 KW of dependable steam capacity and 540,000 KW dependable hydro capacity, making a total of 851,000 KW. The Alabama Power Company has 138,800 KW dependable steam and 280,000 KW dependable hydro capacity. The corresponding figures for the Georgia Power Company are 69,800 KW and 191,000 KW; for the Tennessee Electric Power Company, 95,000 KW and 69,000 KW; for the Mississippi Power Company 6,800 KW and 0 KW; for the Gulf Power Company, 200 KW and 0 KW. The total capacity of steam and internal combustion units excluded as obsolete is 77,780 KW for the Commonwealth & Southern system. This sum does not include what I have called void capacity, which is the difference between the installed steam capacity in a station and the maximum capacity of the boilers.

At this point the defendants rested their case.

SECTION IV.

REBUTTAL EVIDENCE.

At this point certain sections from House Document No. 328, 71st Congress, 2nd Session, were read into the record. These sections were in substance as follows:

Page 3, section 12, to the effect that the operation of storage reservoirs on the Tennessee for the primary purpose of restricting floods in the Mississippi would have little effect on the plans for flood control there. If the reservoirs were operated for the primary purpose of power in the Tennessee basin, the effect on Mississippi River floods would be negligible.

Section 15, on page 4, to the effect that this limited project would have but a relatively small effect in controlling floods. The reference to the limited project is to the seven high-dam project.

Section 13, page 13, to the effect that the low-dam project would require about 32 low dams with locks, and the enlargement of a lock at one existing dam. The estimated cost is $74,709,000, for locks 110 x 600 feet. The high-dam project would require seven dams, the cost of which, with locks 60 x 300 feet, would be $248,925,706, including all power installations at the various dams.

Section 46, on page 23, to the effect that the improvement by a series of low movable dams would have practically no effect on floods. The improvement by high dams with suitable surcharge storage, but without the construction of storage reservoirs on the tributaries, would have but small effect on floods on the Tennessee, and an inconsiderable effect upon the Mississippi.

Section 47 to the effect that the construction of reservoirs

on the Tennessee and its tributaries for the primary purpose of controlling floods upon the Mississippi is unjustified, since the reduction in flood heights would be of no great magnitude, while the diversion of valuable reservoir sites there from natural use for power development would cause economic losses far greater than any flood control benefits which could be expected.

Section 48 to the effect that valuable economies can be obtained by the interchange of power and of storage between the various plants of the system, particularly between high-head plants at storage reservoirs and run-of-the-river plants on the main stream. While it is possible that a central agency set up with authority to control the operations of all the plants in the Tennessee basin might secure a somewhat greater degree of efficiency than could be obtained by voluntary operation among independent power producers, there appears to be no legal means for establishing such an agency by the United States.

Section 19, page 39, under the heading "Erosion and Silting", to the effect that damage due to erosion and silting in the Tennessee River basin is much less than in many sections of the United States. The amount of erosion of agricultural lands does not seem to be great except where farms are neglected. It appears that the denudation of the soil amounts to only one foot in 6,408 years.

The last paragraph on page 39 to the effect that the amount of solid matter carried in solution in the Tennessee River is probably carried to the Gulf before being deposited, and that the amount carried in suspension may or may not be deposited in the lower Mississippi, depending upon the velocity of flood discharges.

Section 26, on page 40, entitled "Natural Flood Storage of the River Channel," to the effect that the river channel has a large capacity for storage which it utilizes in its

natural condition to regulate stream flow and reduce flood discharges. This amount of storage from Knoxville to Paducah is estimated at 14,600,000 acre feet. This storage has a great effect upon the regulation of stream flow and reduction of flood heights over the lower river, although the drainage area at Aurora Landing is 39,895 square miles, its maximum flood discharge is much less than that at Florence, which has a drainage area of only 30,800 square miles. This is due to the large amount of natural flood storage of the river.

Section 32, on page 64, to the effect that while it is possible to secure a large amount of storage on the main stream by projects at Chickamauga, Dam No. 3, and Aurora Landing, the damage done by overflowage and the surcharge required to compensate for natural flood storage displaced renders such storage uneconomical.

Sections 39 and 40, on page 71, to the effect that if a dam is constructed in a stream with a fixed pool elevation, the flood storage capacity of the river channel is eliminated and an increase in flood heights below the dam results. The dam may be so designed and operated that the surcharge storage is equal to the natural flood storage eliminated by the pool of the dam. Under such conditions the dam would not cause an increase in flood heights below the dam. If gates are installed they may be operated to smooth out flood flows by maintaining an average flow during flood periods. This will materially assist in reducing the peak of floods below the dam.

The last paragraph on page 79 to the effect that studies made by the board preparing plans for flood control on the Mississippi indicates that the waters held out by flood reservoirs on the Tennessee would not have a very great effect on floods on the Mississippi, and since reservoirs used primarily for flood control of the Mississippi would

require the use of sites necessary for the proper development of the Tennessee River for navigation, water power and flood control, they would prevent the proper development of those purposes in the Tennessee River.

Section 54, on page 80, to the effect that the erosion of agricultural lands does not seem to be very great in the Tennessee River basin. Measures taken to prevent such erosion would, no doubt, decrease the erosion, conserve the fertile soil, increase to a certain extent the amount of rainfall temporarily held in storage near the surface of the ground, and assist to a small extent in reducing floods which occur during summer months. Any measures taken along this line would be of material benefit to agriculture. Such measures would not have great effect upon the control of floods or low stream flow.

The last paragraph upon page 95 to the effect that the nine-foot water way on the main stream should be developed continuously from its mouth to the head of the development. The development of isolated sections will be of very little benefit. No navigation facilities for a nine-foot water way on the Clinch River should be constructed until the main stream has been developed to the mouth of the Clinch. Any storage reservoirs constructed upon the Clinch should provide for a right of way for navigation and be so designed and constructed that they will permit the installation of nine-foot navigation facilities as soon as required.

At this point the plaintiffs offered in evidence a table appearing on pages 98 and 99 of House Document No. 328 as Plaintiffs' Exhibit No. 56.

It appearing to the Court that it is impracticable to reduce the substance of this exhibit to narrative form, the exhibit is here reproduced in words and figures as follows:

COST ESTIMATE, LOW DAMS; NAVIGATION ONLY

PLAN D

Project	Miles Above Mouth	Pool Elevation		Lift	Foundation	Approximate Length of Dam	Cost of Dam	Cost of Lock, 56 by 360 Feet	Cost of Lock, 110 by 600 Feet
		Lower	Upper						
Paducah to Muscle Shoals:				*Feet*		*Feet*			
Aurora Landing	42.2	302	315	13	Hard Gravel	1,600	$ 1,260,000	$ 910,000	$ 1,490,000
White Oak Landing	83.3	315	328	13	do	1,400	1,200,000	940,000	1,535,000
Perryville	135.6	328	343	15	do	1,500	1,325,000	1,000,000	1,625,000
Wolf Island	192	343	353	10	do	1,400	1,020,000	850,000	1,400,000
Big Bend Shoals	204.6	353	367	14	Rock	1,000	1,040,000	970,000	1,580,000
Colbert Shoals Canal	226.6	367	390.6	23.6	do	.....	1,511,000	924,000	1,880,000
Head Colbert Shoals	234.6	390.6	404	13.4	do	4,500	1,130,000	940,000	1,535,000
Subtotal				102			8,496,000	6,534,000	11,045,000
Muscle Shoals to Chattanooga:									
Dam No. 3	275.1	505	520	15	Rock	4,000	1,950,000	1,000,000	1,625,000
Lock B	285.1	520	530	10	do	.....	48,000	850,000	1,440,000
Milton Bluff	287.7	530	541	11	do	4,000	1,750,000	880,000	1,445,000
Indian Creek Bar	321.2	541	548	7	do	1,300	890,000	760,000	1,310,000
Beards Reef	355.8	548	564	16	do	1,400	1,220,000	1,030,000	1,670,000
Mink Creek	374.2	564	575	11	do	1,400	970,000	880,000	1,445,000
Bellefonte	390.6	575	583	8	do	1,300	890,000	790,000	1,310,000
Widows Bar	.....	583	592	9	do	1,300	200,000	820,000	1,395,000
Subtotal				87			7,918,000	7,110,000	11,640,000
Total, Paducah to Chattanooga							16,414,000	13,644,000	22,685,000
Chattanooga to Knoxville:									
Sherman Hill	468.7	629	641	12	Rock	1,200	810,000	910,000	1,490,000
U. S. Quarry	486.4	641	653	12	do	1,200	810,000	910,000	1,490,000
Sale Creek	494.8	653	663	10	do	1,200	730,000	850,000	1,400,000
Kelly Shoals	510.8	663	673	10	do	1,200	730,000	850,000	1,400,000
Watts Bar	529.9	673	683	10	do	1,200	730,000	850,000	1,400,000
White Creek Island	543.9	683	693	10	do	1,200	730,000	850,000	1,400,000
Half Moon Island	550.6	693	703	10	do	900	670,000	850,000	1,400,000
Caney Creek Island	562.9	703	713	10	do	900	670,000	850,000	1,400,000
Seven Island Shoals	575.1	713	723	10	do	900	670,000	850,000	1,400,000
Sweetwater Island	584.3	723	733	10	do	900	670,000	850,000	1,400,000
Rock Quarry Bar	594.3	733	743	10	do	900	670,000	850,000	1,400,000
Sister Island Shoals	604.6	743	753	10	do	900	670,000	850,000	1,400,000
Coulter Shoals	608.6	753	763	10	do	900	670,000	850,000	1,400,000
Rogers Island	618.1	763	773	10	do	800	640,000	850,000	1,400,000
Georges Branch	630.6	773	783	10	do	800	640,000	850,000	1,400,000
Little River Shoals	634.9	783	793	10	do	700	560,000	850,000	1,400,000
Williams Island	638.6	793	803	10	do	700	560,000	850,000	1,400,000
Subtotal							11,630,000	14,570,000	23,980,000

SUMMARY OF COSTS

110 by 600 feet locks mouth to Chattanooga	$39,099,000
110 by 600 feet locks Chattanooga to Knoxville	35,610,000
Total	$74,709,000
56 by 360 feet locks mouth to Chattanooga	$30,058,000
56 by 360 feet locks Chattanooga to Knoxville	26,200,000
Total	$56,258,000

The reading from House Document No. 328 continued as follows:

The extract at the bottom of page 101 to the effect that the stream regulation would reduce flood stages slightly and increase the low water flow considerably on the lower Mississippi. No reduction in the cost of flood control or navigation on the Mississippi would result, except possibly some reduction in the cost of dredging and channel maintenance. The benefits to the lower Mississippi may be considered as practically immaterial.

Section 7 on page 732 to the effect that the City of Chattanooga may be protected from floods by levees at a total cost of $2,290,700, and annual charges of $677,400. These annual costs are about equal to the annual damage to the City of Chattanooga, which is $687,000 without any flood protection, and it is much greater than the estimate of $85,000 per annum for flood damages if and when Cove Creek and other storage or run-of-the-river projects are developed. If indirect damages, due to interruption of traffic and business and unsanitary conditions, are added to property damages, the total damages resulting from floods would be increased. If relief is not provided by the construction of Cove Creek and other reservoirs and run-of-the-river projects, it is possible that the City of Chattanooga will desire to secure protection by levees.

COL. ROBERT I. RANDOLPH,

Recalled by Plaintiff in Rebuttal, Testified Upon **Direct Examination** as Follows:

I was present during the examination of Mr. George R. Clemens and heard his testimony. Assuming that Norris Dam is beyond the seven-day flow prediction limit at Cairo, but just slightly beyond, and that it would take 7 or 8

days for a flood wave to travel from Norris to Cairo, I find by reference to a water supply paper of the State Geological Survey that the average flow out of the Clinch River at Clinton below the Norris Dam for the week ending April 15, 1927, was 8,680 second feet. Assuming that it were possible to hold out all of that discharge from the flood crest at Cairo by retaining it behind the Norris Dam, the effect would be to reduce that flood crest approximately two-tenths of a foot. That is based upon the assumption that there is a fixed relation between discharge and stage at Cairo.

It is possible to time the operation of reservoirs, but that is subject to human fallibility and the possibility of mistake, with the result that the whole flood may be dumped upon the crest of the down stream flood. The factor of rainfall is very material. The 1927 flood in the Mississippi was not due so much to flood out of the Ohio as it was to rainfall of 18 to 25 inches that occurred in the alluvial valley of the Mississippi. The difficulty of control or prediction increases rapidly according to the distance of the reservoirs from the point to be protected. The main river plants depend upon the operation of the surcharge capacity above the fixed crest dam, and in their operation the effort is made to equalize the flow. A storage dam to be most effective for flood control should be kept empty, but if it serves the other purpose of regulating out-flow for hydro-electric developments it cannot serve the primary purpose of being kept always empty. It does serve to equalize the flood waves by taking off the peaks, but not as effectively as if it were used solely for flood storage. I agree with the statement appearing in the report transmitted to the Secretary of War by the Chief of Engineers, appearing on page 190 of House Document No. 319, to the effect that pools on the Tennessee River can have no value

other than that needed for hourly or perhaps daily variation. I think that Defense Exhibit No. 24, introduced by Mr. Clemens, is misleading. It shows in colors the flood waves the first day, the second day, the third day, approximately, but it shows the wave travelling down a uniform slope, and the waves uniform from day to day. The slope in the Tennessee River is not uniform, the width is not uniform, and the shape of the wave is not uniform. The graph illustrates very well that surcharge storage is not equal to natural storage of the stream and that the measure of control obtained by the manipulation of the surcharge does not obtain as good a control as nature does. In House Document No. 328 there is a graph, page 48, which shows the flood waves in the 1926-27 flood, beginning at Knoxville, and the shape, volume and direction for Knoxville, Louden, Rockwood, Chattanooga, Hales Bar, Guntersville, Decatur, Florence, Savannah and Johnsonville. Each of these waves is successively higher and longer than the preceding one. The peak of that flood in point of discharge was reached at Florence. In any uniform stream the discharge would naturally increase as you go down stream. This graph shows that the discharge at Savannah, 68 miles downstream from Florence, was 15,000 second feet less than the discharge at Florence, and that the peak was reached at Savannah some 3½ days after the peak had passed Florence. The graph shows that the flood had accumulated again at Johnsonville to a point in excess of the discharge at Florence, showing very clearly that the flood went into storage between Florence and Savannah and did not even fill the storage. This natural storage is foolproof. It is beyond the tinkering of human fallibility. The same thing is illustrated for other floods in plate 19 of House Document No. 328 in which there is a graph of the floods of 1901, 1902, 1926, 1927, 1884, 1897, 1886, 1875

and 1876, showing in most cases that the discharge at Florence or above Florence was greater than it was at the mouth.

Professor Woodward testified that the so-called "adopted project" provided for only a one foot freeboard on the main river levees in the Mississippi. As a matter of fact, it provides three feet of freeboard. The main river levees are being built three feet above the fuse-plug levees at the head of the spillways, and those levees are designed to fail when the flood overtops them and comes within three feet of the top of the main river levee. The entire plan is based upon a superflood, which is estimated at some 3,000,000 second feet below the Red River, which is 1,000,000 second feet in excess of the greatest recorded discharge. The main river levees are practically complete. They cannot be raised another two feet, since they have reached their practical limit in height and weight.

Norris and the main river dams would not afford complete protection to Chattanooga. They will lower flood stages in the measure stated by Mr. Kimball, but they will not afford complete protection. The only way of obtaining such protection is by the construction of levees at Chattanooga. The overflow at Chattanooga is all backwater.

The 1917 flood was the highest in the last fifty years. The velocity in that flood was approximately five feet a second, which is a little over three miles an hour. Velocities greatly in excess of that are being overcome in navigation on the Mississippi River every day. In the 1917 flood the railroad track along the top of the river bank was not drowned out, although the main lines were. It would be entirely possible for steamers to tie up at the top of the bank. In fact, as the main line railroad transportation was more or less interrupted by the flood, the river would afford about the only means of through trans-

portation. In the Norris reservoir all that you can hold out from the flood crest is the precipitation within the drainage basin above the reservoir. The maximum flood discharge out of the Clinch at Clinton is 110,000 second feet, so it does not make any difference whether you have 1,400,000 acre feet provided for storage or 2,400,000 acre feet. You cannot hold out any more than the maximum flood.

As I recall Mr. Bowman's testimony, he testified that Norris, Wheeler and Pickwick would raise the stage below Pickwick 2½ feet: That does not mean that it would increase the depth 2½ feet. There will be bar formations caused by the rising stage. In the Mississippi between St. Louis and Cairo the increase in depth is only about four-tenths of the increase in the stage. An effort was made to increase the low water flow in the Mississippi below the Twin Cities by the construction of reservoirs with an aggregate storage of about two and one-half million acre feet. Six of the reservoirs were constructed. Since they were not satisfactory and did not produce the hoped for results, the building of the other 35 has been abandoned.

As to the Clinch and Powell Rivers, Norris Dam is an absolute barrier to navigation even with the elevator or belt conveyor system. It would be impossible to navigate above Norris because of the great fluctuations in the pool levels. A range of 96 to 97 feet between high water and low water makes terminal operations difficult, to say the least. That is too much of a handicap for ordinary commerce.

There have been studies made of the question of silting on the Tennessee River. The one made in 1932 has been introduced in evidence as Defense Exhibit No. 40. There was one made in 1922 which appears in House Document No. 319. Silting in storage reservoirs or in a main river pool will occur in any silt laden stream. Silting in a

storage reservoir is much more objectionable than it is behind a navigation dam. In a running stream where the flow is always maintained through a dam, the normal current washes out the channel. In a main river pool silting may even be advantageous. It builds up the upper shores and ultimately will restore those lands to use. There is some deposit of silt in the stream, and most of it will be in the deep portions of the pool just above the dam. You will not have the same degree of silting in the channel. I agree that succeeding floods flushing the beds of streams have a very beneficial effect on navigation; they keep the channel open. I agree with the final recommendation of Major Fiske, appearing on page 190 of the report, as follows:

"This silting process so objectionable in the storage reservoir is entirely harmless here, where it is realized that in the future, as in the past, nature will keep open the channels sufficiently with the discharge of water entering the stream. It will be proper, therefore, to do everything possible to encourage the rapid build up by silting of submerged farm lands."

I have read the report in House Document No. 319 and consider that it states correct diagnoses of the stream and all the matters discussed.

Upon **Cross-Examination** the Witness Testified as Follows:

I have visited the sites of Wilson, Wheeler and Norris dams, driving through the valley in an automobile. Collectively I have spent a week in the valley. I have made an automobile survey. I went to Wheeler and stayed there long enough to see the work in progress; then to Wilson where I stayed long enough to be shown through the plant. I went to Norris and spent more than half a day looking

over the plans of Wheeler and Norris Dams with the designing engineers. I spent about half a day at Norris Dam going over the work with the superintendent. I spent a day in Chattanooga looking up flood data and inspecting the water front. This is the extent of my survey on the ground. I made no instrumental survey whatsoever, took no soundings and made no analysis of soils. I am depending upon surveys of the Corps of Engineers. I have given no opinion as to the extent of soil erosion in the valley. I have given an opinion as to the extent of silting based entirely upon the surveys made by the Corps of Engineers. I do not think that silting is a serious problem in the main river. If there is more silting in the channel you need more dredging. It is clear that water flows faster over land upon which there are no obstructions than it does over a grassy plot with obstructions. When water flows through a grassy plot it will not carry off as much soil as if it were flowing over smooth ground.

The data in House Document No. 328 with respect to previous floods is based upon records maintained by the Geological Survey. I do not know that the Geological Survey has changed the ratings of the discharges at Savannah and at Johnsonville since the chart was made. It would not make any difference if it had. I do not consider that the maximum recorded flood on the Clinch River is the maximum flood against which protection should be provided. I think that the tables listed on page 72 of House Document No. 328 with reference to the effect on flood stages of Cove Creek storage and main river dams are substantially correct.

At this point the table and cases referred to were offered in evidence by the defendants. It appearing to the Court that it is impracticable to reduce said table to narrative form, the same is here set out in words and figures as follows:

"42. **Reduction of flood heights by storage reservoirs and surcharge pondage.**—In order to determine the reduction of flood heights which may be secured by storage reservoirs and surcharge pondage, the effect which such projects would have upon flood heights on the main stream have been traced downstream from the source of the main stream to its mouth for 10-foot surcharge on Tennessee projects and for certain reservoir projects for the 1926 flood. For this purpose seven cases illustrating the effects which these projects would have had during the 1926 flood were determined as follows:

Case I. Effect of Cove Creek storage.

Case II. Effect of Tennessee River projects operated at normal pool elevation.

Case III. Effect of surcharge pondage secured by 10-foot surcharge on Tennessee River projects in addition to Cove Creek storage.

Case IV. Effect of surcharge pondage secured by 15-foot surcharge on Tennessee River projects in addition to Cove Creek.

Case V. Effect of all storage projects of the entire system and Tennessee River projects operated at normal pool elevation.

Case VI. Effect of all storage projects of the entire system and surcharge pondage secured by 10-foot surcharge on Tennessee River projects.

Case VII. Effect of high dams at Chickamauga, Dam No. 3, and Aurora Landing, assuming reservoirs full at the beginning of flood and normal pool elevation maintained.

"The methods employed and the results obtained are shown in detail in Part II, Appendix B, report on partial survey of the Tennessee River and its tributaries, printed in House Document No. 185, Seventieth Congress first session. Tabulated effect of operations is as follows:

EFFECT ON FLOOD STAGES—1926 FLOOD

Operation	Knoxville Stage (feet)			Loudon Stage (feet)			Rockwood Stage (feet)		
	Natural	Modified	Increase or Decrease	Natural	Modified	Increase or Decrease	Natural	Modified	Increase or Decrease
Case I	....	....	...	....	....	....	25.0	18.4	− 6.6
Case II	14.8	14.8	0	20.5	21.7	+ 1.2	25.0	26.0	+ 1.0
Case III	14.8	14.8	0	20.5	17.6	− 2.9	25.0	14.7	−10.3
Case IV	14.8	14.8	0	20.5	15.8	− 4.7	25.0	13.1	−11.9
Case V	14.8	6.8	−8.0	20.5	10.5	−10.0	25.0	14.6	−10.4
Case VI	14.8	6.8	−8.0	20.5	5.5	−15.0	25.0	10.1	−14.9

Operation	Chattanooga Stage (feet)			Florence Stage (feet)			Johnsonville Stage (feet)		
	Natural	Modified	Increase or Decrease	Natural	Modified	Increase or Decrease	Natural	Modified	Increase or Decrease
Case I	38.4	32.7	− 5.7	26.4	24.6	−1.8	40.5	38.9	− 1.6
Case II	38.4	39.2	+ .8	26.4	26.8	+ .4	40.5	43.5	+ 3.0
Case III	38.4	26.3	−12.1	26.4	20.3	−6.1	40.5	32.5	− 8.0
Case IV	38.4	22.4	−16.0	26.4	17.2	−9.2	40.5	27.4	−13.1
Case V	38.4	28.0	−10.4	26.4	22.9	−3.5	40.5	42.6	+ 2.1
Case VI	38.4	17.6	−20.8	26.4	16.8	−9.6	40.5	27.7	−12.8
Case VII	38.4	40.1	+ 1.7	26.4	29.2	+2.8	40.5	60.0	+19.5

FLOOD STORAGE ON TENNESSEE RIVER

Project	Miles Above Mouth	Crest Elevation	Total Volume in Pool	1926 Flood		Maximum Flood		Flood Storage Provided by 10-foot Surcharge
				Natural Flood Storage in Channel	Natural Flood Storage Eliminated	Natural Flood Storage in Channel	Natural Flood Storage Eliminated	
PROPOSED DAMS			D.s.f.	D.s.f.	D.s.f.	D.s.f.	D.s.f.	D.s.f.
Aurora Landing	42	352	775,000	1,525,000	700,000	2,400,000	775,000	505,000
Pickwick Landing	206	408	285,000	615,000	260,000	875,000	285,000	210,000
Dam No. 2	259	505	250,000	225,000	100,000	325,000	160,000	.....
Dam No. 3	275	549	285,000	605,000	235,000	940,000	250,000	215,000
Guntersville	357	589	203,000	558,000	203,000	900,000	203,000	168,000
Hales Bar	431	626	50,000	155,000	50,000	450,000	50,000	0
Chickamauga	472	676	225,000	205,000	190,000	750,000	225,000	198,000
White Creek	543	714	68,000	83,000	63,000	220,000	68,000	73,000
Marble Bluff	577	747	35,000	40,000	32,000	195,000	35,000	35,000
Coulter Shoals	608	802	95,000	55,000	50,000	245,000	95,000	50,000
Total			2,271,000	4,066,000	1,883,000	7,300,000	2,140,000	1,454,000
HIGH DAMS								
Aurora Landing	42	408	6,927,000	2,140,000	2,000,000	3,275,000	2,690,000	.....
Dam No. 2	259	505	250,000	225,000	80,000	325,000	100,000	.....
Dam No. 3	275	605	3,795,000	1,163,000	1,080,000	1,840,000	1,327,000	.....
Hales Bar	431	626	50,000	155,000	50,000	450,000	50,000	.....
Chickamauga	472	714	1,547,000	288,000	273,000	970,000	792,000	.....
Marble Bluff	577	757	70,000	40,000	40,000	195,000	70,000	.....
Coulter Shoals	608	812	145,000	55,000	55,000	245,000	140,000	.....
Total			12,784,000	4,066,000	3,578,000	7,300,000	5,169,000	.....

Assuming that the surface area of the reservoir at Wheeler will be 66,000 acres at an elevation of 555, a five-foot draw down would afford about 330,000 acre feet of storage. That would supply some 23,000 cubic feet per second of discharge for one week. I would say that such a reservoir is good only for knocking the crest off of a flood wave.

I do not know the nature of the bars on the lower Tennessee River. The critical cross sections, that is, the shallowest depths, occur in rock cuts. That bottom does not shift, but there is no assurance that sand bars will not form. Sand bars move downstream like a wave. The present minimum depth in the river is not caused by sand bars.

One cubic foot of water per second in the course of 12 hours will amount to one acre foot. If you take the average summer flow of 16,000 cubic feet per second you could release or store up 16,000 acre feet in 12 hours. Calculating that on the basis of the 66,000 acres covered by the Wheeler reservoir at normal pool level, the 12 hour discharge at that rate would amount to less than three inches over the surface of the pool.

There is a fuse-plug levee on the Mississippi at the head of the Birds Point-New Madrid spillway. That is approximately 350 miles above the mouth of the Arkansas. I think the Birds Point-New Madrid flood way is more than 30 miles long but the water does come back into the main stream between the levees and runs down to the mouth of the Arkansas. The levees in the flood way have not been started.

The project, to which I refer, of the construction of reservoirs above the Twin Cities was undertaken a good many years ago, about 1880. Those dams were designed to maintain a low-water flow at St. Paul of about 5,000 second feet.

At this point portions of the annual report of the Chief of Engineers of the United States Army, Part 1, for 1915, were read. The substance of these extracts was as follows:

Extract appearing on page 1932. The original project was adopted by the River and Harbor Act of June 14, 1880. The amount expended on the original project was $656,805 for new work and $100,857 for maintenance. The construction of the reservoirs has resulted in a greater channel depth and more uniform flow in the Mississippi River, and has made possible continuous navigation on some stretches where it was formerly subject to interruption on account of low water. The reservoirs are of great value in mitigating the effects of floods in the river above St. Paul.

At this point an extract from Part 1 of the annual report of the Chief of Engineers of the United States Army for 1926 was read. The substance of the extract appearing on page 1067 of the report was as follows:

The construction of reservoirs has resulted in a greater channel depth and more uniform flow in the Mississippi River below St. Paul, and has made possible continuous navigation on some stretches above St. Paul where formerly it was subject to interruption on account of low water, and has assisted navigation at and immediately below St. Paul. Incidentally, the reservoirs are of value in mitigating the effects of floods in the river above St. Paul.

The Testimony of the Witness Continued:

Undoubtedly the observation of the Chief of Engineers is correct. The construction has raised the low water plane but it has not accomplished what they expected to

do. I think that it is true that at the time of the adoption of this project the logging business was the principal one in that region. That business is not as flourishing now as it was.

O. G. THURLOW,

Called as a Witness on Behalf of the Plaintiffs in Rebuttal Testified upon **Direct Examination** as Follows:

I have the information respecting the existing and prospective load and capacity of the Alabama Power Company and the Commonwealth & Southern System in this area. I am retained by the Commonwealth and Southern Company in an advisory capacity. I have been connected with the southeastern companies in that system since 1912. I have had a staff of engineers working on system planning and power plant layout of these companies as they came into the system, since that time. In the early stages of our work practically all of the operating companies were operating and building in an isolated manner. From the beginning of our work we have always considered this inter-connected system as a whole, and all those various interests are now included in the orderly arrangement we have here. We have made many studies of load and prospective requirements and capacity; the latest of which was completed in December, 1933.

That was an extensive study; it took a good-sized staff of engineers about three months to make the complete study. This was made entirely for our own benefit. It was prior to this power survey of the Federal Power Commission and prior to any discussion of a contract with the Tennessee Valley Authority.

Our 1933 diversified demand upon the whole system was 649,655 KW and an undiversified demand of 693,300 KW.

At this point the following occurred:

"Mr. Fly: Your Honor, I assume that the witness is going into the problem of the surplus and I merely want to remind the Court of our earlier objection and exception to that line of testimony, which I assume you will permit us to carry through here?

"The Court: Yes."

The diversified demand, that is, the larger figure, is the figure obtained by adding the peak loads of the various operating companies, and the undiversified demand is the maximum demand on the system as a whole at any time during the year.

These figures are later than those given by Mr. Thomas, because we have included the load of the South Carolina Power Company, and also of the Birmingham Electric Company, which is our customer. Our estimated load for diversified demand for 1936 is 737,000 KW, with an undiversified peak demand of 768,400 KW. For 1940, it is 904,000 KW with an undiversified peak demand of 940,200 KW. Our study of capacity indicates a capacity of 904,000 KW, after allowing for the largest unit at 60,000 KW being out for repairs. We have sufficient capacity to carry a load up to the year 1940. I think about 40% of the load in the area considered by Mr. Thomas is served by the Commonwealth and Southern system.

Our study of capacity is based upon rainfall and stream flow records, which go back over a great many years, and based upon making the most economical use of the storage by an interconnected system and by the joint operation of these various hydro and steam plants, so as to get the greatest use out of the stream flow. The extreme low-flow occurs about once every ten years. It extends over a period of three or four months in the fall of the year.

That would be four months out of a total of 120, slightly under 3% of the time. Nevertheless, all our computations as to capacity are based on low flow capacity. We have had our operating men report on all available plants, good and bad, and they reported on their ability to carry the load. We investigated the reports and discarded a great many plants as not being worthy of consideration. Mr. Thomas classified as obsolete and discarded the following: the 9,000 KW at Nashville; 10,000 at Gadsden; 5,000 at Montgomery; 3,000 at Mobile; 11,300 at Birmingham; 1,200 at Gulfport and 4,700 at Meridian, and other miscellaneous small plants. The total is roughly 78,000 KW. The Nashville plant has a capacity of 48,000 KW and we use and report 40,000 KW. We threw out 8,000 KW ourselves on account of boiler capacity. That plant is perfectly good for 48,000 KW. At Gadsden we threw out 10,000 KW. The plant was operated in 1932 for 144 hours and can go on the system any time on ten hours notice at full capacity. In Montgomery we reported 4,000 KW. We can put 2,000 KW of that in the system in about a week. The Mobile plant was operated each year during the past four years. Some of these plants are in excellent condition and others are in fair condition.

The diversified demand of Commonwealth and Southern in 1934 is 704,865 KW and the estimated capacity of the system is 904,000 KW, with a 60,000 KW unit out as a spare. Our estimated growth by 1937 amounts to about 4-4/10% compounded annually after deducting the load in the Tennessee Valley Authority area. That load is roughly 17,000 KW. The determination of system capacity on an interconnected system requires almost a life time knowledge of the plants, the industries, customers, personnel, methods of dispatching, river flow records, and experience. This last study that we have made for ourselves was made

by men who spent ten and twenty years on this particular specialty, and they took three months to arrive at the answer. I am satisfied that we can carry a load of 904,000 KW during the year of lowest flow on record with the system as it is today, and that the load will not reach that figure until approximately 1940. In the establishing of the plants on the system, consideration has been given to the existing and prospective load centers.

I am a graduate of Massachusetts Institute of Technology, class of 1904. I was connected with the Board of Water Supply of New York, designing engineer of Puerto Rico Irrigation Service, and a member of the advisory board of the New York State St. Lawrence Commission in 1931 and 1932. I have been in charge of engineering work for the Alabama Power Company and these various companies of the Southeastern group since 1912. I was with those companies when the War Department sold the power plant at Gorgas to the Alabama Power Company in about 1923. In 1918, I was consulting engineer to the Federal Government at Muscle Shoals for about a year, in the planning of Wilson Dam, until Col. Cooper came back from France. I am familiar with the eleven-dam project of the East Tennessee Development Company. That was a combination of units that are now in the Commonwealth and Southern system. An application for permit was filed with the Federal Power Commission in 1926 and disapproved in 1931. It can be identified as application No. 638 of the East Tennessee Development Company, the report appearing on page 218, annual report of the Federal Power Commission for 1926. The application was rejected due to necessity of giving consideration to development of the power resources above Muscle Shoals in connection with the nine-foot navigation project adopted by Congress. The application contemplated 300,

000 primary horse power, with proposed installation of 600,000 horse power.

A large block of surplus power available for sale in the territory makes it difficult to plan for the future, both for the power companies and for private industries. In the Birmingham district there is a waste of gas that could be converted into power if we knew that a tremendous surplus was not going to be dropped down here. I have made plans with various steel companies for the utilization of blast furnace gas in the district for a total that will amount to 1,000,000,000 KWH per year, and would reduce the cost of pig iron about a dollar a ton. That much power is being wasted, and it is an economical and practical method of utilization. The same thing is true of the industries using a great deal of steam, and the coke industry.

As to its bearing on the questions of decentralization and encouragement of industry and the location of power plants, if we could disregard this surplus and if our credit wasn't damaged we could advance the installation of industries even in times like this in this State by months, possibly by years. We have a pulp industry talking of moving into Alabama, and under present conditions the logical thing to do would be to put very expensive boilers and turbines into their plants. That requires capital and credit. Ordinarily we could create plenty of capital that would go ahead in cooperation with those industries, and put in a plan that would be interconnected with the system as a whole and would advance industry. The same thing applies to the chemical industry, which is rapidly moving to the gulf coast. The potential indefinite extension of unallocated energy has a serious effect on our credit, and makes it practically impossible to study the development of this system in a logical way. It inter-

feres with logical planning for these industries and for this interconnected system as a whole.

I have a general knowledge of the design of the Corps of Engineers for the lock at the Wheeler dam site. In that plan provision was made for a small hydraulic turbine in the concrete walls of the lock for power for actuating the locks. Apparently it would be possible to put in 700 or 800 horse power. I have designed Penstock openings and draft tubes and am familiar with their installation. It was not necessary at Wheeler Dam to purchase and install the hydro electric unit in order to make an emplacement for future installation, or to design the forms. You would not have to buy and install a unit. I am familiar with both the Wheeler and Pickwick sites and I know of no reason why they could provide emplacements at Pickwick but could not provide them at Wheeler without actually buying and installing one unit.

In 1925, I received the Howard Potts Medal of the Franklyn Society for my work in hydraulic designing, and I have been made a Doctor of Engineering by the University of Alabama.

Upon **Cross Examination** the Witness Testified as Follows:

I have been working on these figures since 1912. I have not included anything in my study except the units in the Commonwealth and Southern system. With respect to the question as to how long I have been preparing my testimony with reference to the effect of the presence of the Tennessee Valley Authority upon the electric industry and other industries generally, I have been living with that ever since they started to build Wilson Dam, or to talk about it. The first Bill was passed, I think, in 1916, and since then we have had a white elephant in our backyard.

I did not know that I was going to testifiy in this case until somebody mentioned it to me yesterday. That plan for Wheeler Dam was given to me this morning by one of my engineers. I was not authorized by the Commonwealth and Southern Company to represent them in this proceeding. I was requested to appear by counsel for the plaintiffs.

The areas shown upon defense Exhibit No. 98 as being served by the Commonwealth and Southern companies and other companies are substantially correct. Most of the territory within a radius of 100 miles of Wilson Dam is served by the Commonwealth and Southern group. There is a small area served by the Electric Bond and Share group. The City of Memphis is served by the Electric Bond and Share group, but it is not within 100 miles of Wilson Dam. It is within 100 miles of Pickwick. I have no information concerning the corporate stock relationship between the Commonwealth and Southern and Electric Bond and Share or National Power and Light. I have no knowledge as to any relationship between them, or that the National Power and Light owns a 20% stock interest in the Commonwealth and Southern Company, but I know what has been done to the credit of these Southern companies.

The transmission lines to Wilson Dam are owned by the Alabama Power Company. That line to the North may be owned by a separate transmission company, but if so it is one of the Commonwealth and Southern group. It is true that those are the only people there at the dam with transmission lines to get the power, with the exception of the nitrate plant.

The operating companies of the Commonwealth and Southern system answered the questionnaire sent out by the power survey and supplied the requested information. That information was accurate and correct. I think they

are practically the same figures as the ones I have given here.

For the immediate future I have assumed a 4 4-10% growth compounded annually. Briefly, that assumption is based upon our past history, our knowledge of the industries and their history and of what plans for the future are, the growth of population, and the possible increases to various classes of customers. It is true that past growth has averaged 8% or better but that was at a time when we were taking on new systems, and before we had natural gas lines in this territory to compete with us. There is no question but that long before a load of 904,000 KW is reached, we would want to install in this area more modern plants than the partially obsolete ones that have been mentioned. There will be a need for additional capacity at proper locations. This chart entitled "Consolidated System Forecast, Southern Group, Commonwealth and Southern Corporation," is a document that was filed with the Federal Power Commission. It omits the Birmingham Electric load, since they made a report by themselves. Excluding the Birmingham Electric, it does represent the consolidated system forecast. (At this point the chart referred to was offered in evidence as defense Exhibit No. 107, which is omitted from this narrative).

It would be natural to substitute new capacity as the load increases for the less efficient operating units in the system. It depends on the number of hours use to which the particular plant may be put. If you are justified in making the expenditure for new units you would select the proper location in which to place them.

In the last few years the Commonwealth and Southern Company has had no occasion to attempt to borrow money or obtain credit, but I know what the price of the bonds

and preferred stock of those operating companies was, and what it is today.

With respect to this use of waste gas by industries, we have been studying that since 1912. In that time we have put in one first-class plant in this district, and we have been building up a load to the point where there is a justification for that class of plant. The impression that I meant to give was that the existence of this surplus makes it difficult to plan and provide capital for developments of this sort.

It is true the Government, at the time of the construction of the Gorgas plant, agreed to contract to convey it to the Alabama Power Company and merely carried out its contractual obligations when it did so.

In speaking of the Tennessee Valley Authority area, I included those counties in North Alabama and Mississippi included in the contract of January 4, 1934. The estimated load in KWH for that area in 1937 is 70,000,000 KWH. It is true that demand has increased materially throughout this area since 1933. There has been no increase in capacity during that time.

The East Tennessee Development Company to which I referred never did obtain either a license or permit. I know that they never made any showing of actual financial ability to go forward with the project but they were not called upon to do so. The eleven dams were to be at locations determined in a general way by the engineers. The only site that you might say had been determined was the present site of Norris Dam, and that was probably questionable. At that time they were of the opinion that there was need for additional power development in that region to the extent of eleven additional hydro electric dams. That was prior to 1929. Three or four of those dams were to be on the main river and the rest

on the tributaries. They made the application in 1926. Very little was done between then and 1930 when the application was finally rejected. No new application was ever filed or any further action taken by that company.

The effect of a large block of power in private hands would not be the same as the effect of that same power under control of Tennessee Valley Authority. It would be a different situation; we would go to Montgomery and march in data to the Public Service Commission and get proper protection.

The rock foundation at Wheeler is siliceous limestone and has quite a few crevices in it. It is not as good as at Wilson, and the rock at the Pickwick Landing site is not as good. I looked over that site and finally, for policy reasons, selected the Parkers Landing site. It is not any better power site than Pickwick, but one abutment would be in Mississippi and I wanted the Mississippi Power Company to have a hydro electric plant. I did not study the rock foundation at the Pickwick site. It might be true that the horiontal seams at Wheeler make it impossible to place draft tube emplacements below the intakes at a future date and make it necessary to back up the reclassifications with draft tubes actually installed. That might be good judgment. I have not seen the last design of the Army Engineers for Wheeler Dam. As I recall, their plan when I talked to them did not include emplacements for generators. I don't know whether the plan has been changed.

In 1929, the total generation on the Commonwealth and Southern system was 3,444,000,000 KWH. In 1934, the total generation was 3,311,021,000 KWH. Losses suffered during the depression have been practically completely recovered at the present time. In our estimates for 1936 we are counting on a very liberal increase in the con-

sumption of power per residential customer and we are counting on a further liberal increase in that consumption by 1940. It is my opinion that those increases will take place. The residental sales that we used in working up our forecast were 220,500,000 KWH in 1933, 250,000,000 KWH in 1934, 330,000,000 KWH for 1935 and 630,000,000 KWH estimated for 1940. Those increases are due primarily to improvement in rates and reduction in the cost of appliances. There is no disputing the fact that in residential business there has been a decided improvement since the creation of the Tennessee Valley Authority. There has also been an improvement in total business. This country is growing. The estimated increases in industrial load by 1940 are small in some cases and liberal in others. In the chemical industry in 1929 we had an actual load of 257,600,000 KWH. Our estimated load for 1940 for that industry is 260,000,000 KWH. So far as power consumption is concerned we do not believe there will be any greater increase in the chemical industry in the South. That industry is going to grow faster than the rate shown for power consumption. By 1940 the industrial sales will have passed the peak of 1929. We had some surplus capacity in 1929. I cannot say just what it was. It was not very much and we were actively at work building new plants to take care of the load we expected to get. We have added five very large plants since 1929. Our estimate for industrial load in 1936 is about the same as our actual load in 1929. In estimating capacity I have counted out for emergency only one steam unit in the whole territory included. That is the judgment of our operating engineers who have to keep service on the line, and we are backed by a world of experience in doing that. (At this point there was offered in evidence as defense Ex-

hibit No. 108 the load forecast of the Commonwealth and Southern system, which was identified by the witness. This exhibit is omitted from this narrative.)

(At this point there was offered in evidence as defense Exhibit No. 109 the paper entitled "Break Down of the Industrial Forecast," which was identified by the witness. This exhibit is omitted from this narrative.)

Upon **Redirect Examination** the Witness Testified as Follows:

I have no further explanation to make of these documents. There is nothing in them that tends to affect the conclusions suggested on my direct examination this morning. The coal companies are very large consumers of electric energy from the power companies. Competition from natural gas has come in since 1929.

All of the transmission lines from Muscle Shoals were built with the permission of the War Department. In 1928, we received letters from the Secretary of War concerning the amount of power which we were using at the Wilson Dam, complaining because we were not using more power. The discussion extended over a number of months and finally ended with the preparation of a contract which was never carried out. In 1930 we built that line to Nashville. The Government Engineers urged us to build it in order to take some of the power from Muscle Shoals. The War Department gave us the necessary authority to go across the river. There was not objection from the War Department upon the theory that we were trying to monopolize the outlet from Muscle Shoals; the whole history of the thing was just the opposite. We operated in the purchase of power from the War Department under a contract that practically gave them the

right to cancel it at any time. No permanent provision with reference to that power could be made under those contracts.

At this point counsel for the plaintiffs called the attention of the Court to the report of the Assistant Secretary of War for the fiscal year ending June 30, 1934, which appears, beginning on page 27 of the annual report of the Secretary of War for the fiscal year ending June 30, 1934, stating that the purpose of calling attention to this document was to show that there were no references in it to the Tennessee Valley Authority program.

At this point counsel for the plaintiffs read into the record marked passages on pages 11, 12 and 13 of House Document No. 395, 73rd Congress, 2nd Session, entitled "Development of the Rivers of the United States," said section being part of a supplemental letter of the Secretary of War dated April 20, 1934, the substance of which is as follows:

Soil erosion, except along the banks of the streams, appears to be more closely allied with reforestation and restoration of plant cover than with stream improvement. Reforestation plays an important part in flood control and soil erosion but it may be carried on quite independently of river improvement works. The recommendation of the Secretary of War included the immediate preparation of a report on investigations made during the past seven years, the adoption of a plan based upon this report and the authorization for its construction, lump sum annual appropriations and the construction of projects by the War Department, except irrigation projects, which should be left in the Interior Department.

At this point counsel for the plaintiffs called attention to the financial condition of the municipalities in the general area, specifically to the fact that in this court there is a receivership pending in Docket No. 56, Northwestern Division, for the defendant, City of Tuscumbia, and in Docket No. 65, Northwestern Division, a receivership of the City of Florence, and similar proceedings pending for the City of Decatur in Docket No. 349, Northeastern Division. At this point there was offered in evidence by the plaintiffs as plaintiffs' Exhibit No. 57 the report of Major Fiske, which was transmitted as a part of a letter from the Secretary of War set out in House Document No. 319, 67th Congress, 2nd Session. The substance of this exhibit was as follows:

The channel of the Tennessee in the past has been remarkably free from shifting bar formations and other silt. This is significant since most of the tributary streams are actively engaged in eroding their beds and drain regions of considerable declivity where natural surface erosion has been in progress for ages and where this erosion has become accelerated as the result of devegetation.

To completely regulate the flow of a river like the Tennessee in order to make it uniform the year around would be on a par with building a sewer system without provision for flushing. What the intermittent discharge from a flushing tank does for a sewer, flood flow does for a river. The complete elimination of floods would prove a detriment rather than a benefit.

It is alleged that debris deposits are now making their appearance in the navigable portions of the river, but the information is by no means conclusive. It is conceivable that the scouring action of floods may in time remove such deposits. At any rate, it would be premature to

conclude that erosion has been accelerated in the Tennessee basin to the extent where it is beginning to overtax the transporting capacity of the main river. The rapidity with which the lands submerged by the Hales Bar Dam are silting up is of interest. The prospects are that much of this land will be built up above the surface of the pool within the next five years and again become available for agricultural purposes better and richer than before the dam was built. The same process may take place on the flowage lands above proposed dams elsewhere in the basin.

At this point counsel for plaintiffs referred to the annual report of the Tennessee Valley Authority, specifically to appendix B on page 21, which appears as House Document No. 82, 74th Congress, First Session.

The defendant Chemical Bank and Trust Company introduced in evidence the provisions of the Trust Indenture from Alabama Power Company to United States Mortgage and Trust Company as Trustee (Chemical Bank and Trust Company, successor trustee), which constituted a lien upon all of the properties involved in the suit, the release of which for the purposes of transfer to TVA had been requested by Alabama Power Company.

In support of the averments of its answer and application for cross-relief, said Chemical Bank and Trust Company made tender of proof stated by counsel for said trustee to prove, or tend to prove, the following:

(1) That the purchase price of $1,150,000 for the properties set forth in the contract of January 4, 1934, and the price of $29,518 for the properties located at Athens and Belle Mina, and the price of $1,000,000 for the properties

set forth in the contract of August 9, 1934, do not respectively represent the full or fair market value of the respective properties, nor make any allowance for severance damage or for going concern value.

(2) That the book values of the physical properties involved under the contract of January 4, 1934, and the Athens and Belle Mina properties was $2,036,828.03, for which a consideration of $1,179,518 was proposed to be paid.

(3) That the book value of the properties involved in the August 9, 1934, contract, was $1,925,815.60, for which $1,000,000 was proposed to be paid.

(4) That the appraised market value of the properties was not less than $3,160,000, after allowance for depreciation and exclusive of any allowance for going concern value or severance damage to the system.

(5) That the severance damage to the system was not less than $1,600,000.

(6) That the value of the business attached added not less than $300,000 as going concern value.

(7) That the prices fixed in the contracts were induced and caused by the illegal threat of TVA to construct duplicating lines and facilities with its own or PWA funds and to operate in competition with Alabama Power Company.

(8) That the prices proposed to be paid for the release of the properties did not represent their full or fair market value.

(9) That there are in excess of $70,000,000 of bonds issued under the Indenture of which Chemical Bank and

Trust Company is Trustee, secured by the lien of said Indenture.

The Court, on objection by Tennessee Valley Authority, declined to entertain evidence in support of the offer above set out, asserting that if it should appear that the issues presented by Chemical Bank and Trust Company became necessary for consideration in the protection of the Trustee or bondholders, the offer would be given further consideration.

The foregoing narrative of the evidence and testimony does not record the objections of plaintiffs to testimony and exhibits offered by Tennessee Valley Authority relating to siltage, erosion, flood control and national defense.

Here both sides rested the case.

Wherefore, the said defendants pray this Honorable Court to sign and approve the foregoing as the narrative statement of the evidence taken in this cause and to incorporate the same at a part of this record in this cause, which is accordingly ordered and done this 11th day of April, 1935.

W. I. Grubb,
Judge of the United States District Court for the Northeastern Division of the Northern District of Alabama.

The undersigned Solicitors of record for the plaintiffs hereby consent to the approval and signing of the foregoing narrative.

Cabaniss & Johnston,
By Jos. F. Johnston,
Solicitors of Record for the Plaintiffs.

The undersigned Solicitor of record for the defendants City of Florence and City of Decatur hereby consents to the approval and signing of the foregoing.

W. H. Mitchell,
Solicitor of Record for the Defendants
City of Florence and City of Decatur.
By Charles J. McCarthy.

(Filed in office, April 11, 1935, W. S. Lovell, Clerk.)

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
versus
Tennessee Valley Authority, et al.
No. 355
In Equity.

FINDINGS OF FACT AND CONCLUSIONS OF LAW

In accordance with Equity Rule 70½, the Court, in deciding the above suit in equity, finds the facts and states separately its conclusions of law thereon as set out below:

FINDINGS OF FACT.

1. The organization and certain characteristics of the defendant, Alabama Power Company (called AP Co or Alabama Company), are stated in subsequent findings.

2. The organization and certain characteristics of Tennessee Valley Authority (called TVA) and Electric Home and Farm Authority, Inc. (called EHFA) are stated below.

3. The municipal defendants have all entered into or propose to enter into long term (20 year) contracts with TVA for the purchase of their entire supply of power for municipal electric distribution systems. All except the City of Athens expect to construct or acquire their systems, without cash expenditure on their part, by means of loans and grants from the Public Works Administration. The City of Athens owns its distribution system and derived its supply at wholesale from the Alabama Company prior to the contract of January 4, mentioned below. Under that contract the Alabama Company has been delivering the current to Athens for account of TVA, un-

der the latter's contract with the City of Athens for a 20 year supply of its requirements.

4. The service area and utility properties and franchises proposed to be transferred by the Alabama Company to TVA by the contract of January 4, 1934, and characteristics of that contract are stated below.

5. Plaintiffs are holders of less than a majority of the preferred stock of the defendant Alabama Company, as alleged in the bill of complaint, and became such stockholders at a time prior to the matters complained of in the bill of complaint.

6. Approximately 1900 preferred stockholders of the Alabama Company, holding over 40,000 shares of the preferred stock thereof, have associated themselves with a Preferred stockholders protective committee and authorized their names to be joined with the plaintiffs of record in this case as parties plaintiff.

7. This action was for the purpose of protesting against performance of the contracts of January 4th and August 9th, hereinafter mentioned, and against surrender of the corporate franchises, business and public service to what was conceived by the protesting stockholders to be illegal commercial operations in the Alabama Company's service area threatened and proposed by TVA in competition with the Alabama Company both directly and through municipal operations under contract with and to be supplied with electricity by TVA.

9. In September, 1933, TVA announced its wholesale and retail rate schedules, which are shown by the evidence to be materially lower than corresponding schedules of the existing utilities in the area. Following this action

numerous municipalities in the area began to make efforts to construct municipal systems with which to distribute TVA current, and Public Works Administration (called PWA) gave assurances of favorable consideration of applications for loans to that end.

10. Under these circumstances Commonwealth & Southern Corporation (called Commonwealth) negotiated a contract for its operating subsidiaries: Alabama Power Company, Georgia Power Company, Mississippi Power Company, and Tennessee Electric Power Company, by which all except Georgia Power Company were to sell out to TVA in the respective contract or "ceded" areas.

11. The contract was negotiated by officers of Commonwealth (who kept the officers of the Alabama Company informed and consulted with them), set out as Exhibit No. 5 to the Bill of Complaint, dated January 4, 1934, and was submitted to the Board of Directors of the Alabama Power Company for the first time on January 6, 1934, after its signature by Alabama Power Company officials.

12. Under like circumstances, the contract of August 9, 1934, was executed, calling for the transfer to TVA of the 14 urban distribution systems, in the ceded area, referred to in Section 5 and in Exhibit "B" of the contract of January 4, 1934. TVA on January 24, 1935, exercised its right not to purchase said urban distribution systems and elected to terminate the contract.

13. The contract of January 4, 1934, in effect isolated the urban distribution systems, in that the transmission lines serving them were to be transferred to TVA. Section 5 of the contract of January 4, 1934, contemplated sale of these urban systems to the respective municipalities, to be supplied with power by TVA. The cities could not pay

cash or could not agree on the price with Alabama Power Company. Certain of the towns had, definitely or tentatively, allotments or assurances of federal loans with which to construct competitive systems. In this situation the contract of August 9, 1934, was negotiated, which contemplated the transfer of the urban systems to TVA direct for operation by it subject to such ultimate disposition as TVA had agreed or might agree with the towns. In case of all distributing (retail) agencies contracting for supply from TVA, the TVA city gate or power supply contract fixes the resale rates to be charged, the accounting to be followed and controls the disposition of earnings and reserves of the distributor.

14. The withdrawal from service area by Alabama Power Company which would result from performance of the contract would cover five entire counties and parts of two additional counties, serving a population of approximately 190,000, including approximately 10,000 individual customers or approximately 1-10 of the entire number of customers directly served by the Alabama Power Company.

15. Plaintiffs made demand upon the management of defendant Alabama Company, for action by the management and the corporation as stated below. This request was made both upon the officers and directors of Alabama Power Company and also upon Commonwealth as owner of the voting control of the Alabama Company.

16. The whole of the common stock of the defendant Alabama Company is owned by Commonwealth & Southern Corporation, a corporation organized and existing under the laws of the state of Delaware. There are outstanding 3,775,000 shares of Alabama Power Company's

common stock, of equal voting power, share for share, with the preferred, of which 376,207 shares are outstanding. The preferred stock was issued and sold at cash prices ranging between $93 and $102; all as alleged in the bill of complaint, Section 7.

17. The several demands of the stockholders (plaintiffs) were made in writing, protesting against performance of the contracts of January 4th (original bill, Exhibit No. 5) and August 9, 1934 (original bill, Exhibit No. 6), including the amendatory agreement of February 13th, 1934 (original bill, Exhibit No. 5-a), asserting their invalidity and the invalidity of the TVA electricity program, including the EHFA agency contract mentioned below (Original bill, Exhibit No. 10), and demanding action by the management and by the Board of Directors as well as by Commonwealth to protect the company in the premises.

18. The respective demands and protests were considered at meetings of the Board of Directors of the Alabama Company and the requests of the stockholders were severally declined. Commonwealth & Southern declined to call a meeting of stockholders to take action. The evidence adequately establishes the efforts of the stockholders to obtain the relief prayed by the bill of complaint through the corporation and its management, their failure to get action, the futility of further effort and the reasonable necessity that suit be immediately filed. Although instituted in the State court, the evidence is sufficient to show compliance with the requirements of federal equity Rule No. 27. Copy of the bill of complaint was filed with the management before its filing in court.

19. Assuming the invalidity of the TVA power program or of its acquisition for operation of the proposed prop-

erties, the failure of the Alabama Company to withdraw from participation in such illegal objectives assuring immediate (and threatening progressive) loss of franchises, business and service area, involved a breach of duty on part of the management and Board of Directors.

20. The defendant Alabama Power Company is a corporation organized under the laws of Alabama. Its principal place of business is in Jefferson County, Alabama. It is engaged as a public utility in the generation, transmission and distribution of electric power generally throughout the State of Alabama, its lines or service reaching 66 out of the 67 counties of that state.

21. Certain system and physical characteristics of the Alabama Company are substantially as set out in the bill of complaint in Section 4. The history of the development of hydro-electric power generation facilities by the Alabama Company under grants and licenses from the United States on navigable streams is correctly set out in Exhibit No. 12 to the bill of complaint.

22. Alabama Power Company holds grants, franchises, licenses, certificates of convenience and necessity for its service throughout the State. These are classified as follows:

a. Direct franchises from municipalities to occupy public streets.

b. County franchises for the occupation of county roads.

c. The right under Section 7197 of the Code of Alabama of 1923 to occupy the public highways of the state.

d. Certificates of convenience and necessity issued

by the Alabama Public Service Commission under Section 9795, Code of 1923, enacted in 1920.

e. Licenses issued by the Federal Power Commission under the Federal Water Power Act (41 Stat. at L. 1063, U. S. C. Sec. 791-823); and direct grant by Act of March 4, 1907 (34 Stat. at L. 288).

23. Within the area covered by the contract of January 4, 1934, the nature of the franchises is as follows:

a. Unexpired franchises from the following towns: Albany, Ardmore, Austinville, Cherokee, Courtland, Decatur, Elkmont, Falkville, Hartselle, Hillsboro, Leighton, Moulton, Red Bay, Rogersville, Russellville, Town Creek, Trinity. The company's franchises at Florence, Sheffield and Tuscumbia have expired, but the company continues to serve those cities and their residents. The company is the sole present means of servicing these cities, there being no other distribution system in their respective corporate limits. The Power Company pays taxes and licenses covering its utility properties and operations to all the above named towns and serves the public needs of the towns as well as their citizens and residents, and suburban areas surrounding the towns.

b. The company owns perpetual public road franchises outside of the municipalities issued by the counties of Colbert, Franklin, Lawrence, Limestone, Morgan and Cullman.

c. Certificates of convenience and necessity were issued from time to time to the company by the Alabama Public Service Commission for extensions of the company's service area.

24. The licenses granted to the company by the Federal Power Commission, as well as the State, county and

municipal franchises and certificates, cover the contract area in the sense that they contemplate service by the Alabama Power Company within the entire area, and the court finds that any exclusion of Alabama Power Company from that area would result in a loss of such franchises and of the business conducted under same and a curtailment of its service area.

25. The gross annual revenue of the company from the properties located within the area amounts to approximately $750,000.

26. One of the first corporate acts of TVA after its organization was to formulate and announce a power policy to govern the commercial distribution of electric power by TVA. The evidence establishes the fact that the Board from the outset has considered that it has general corporate discretion as to the establishment and extension of its electric power policy. In establishing a power policy the Board was not primarily considering merely the question of disposal of power produced at Muscle Shoals no longer required for governmental purposes as a result of overbuilding, obsolescence of plants or termination of war purpose. Nor was it considering disposal of prospective increases in electric power to be unavoidably created in excess of some governmental requirement. It was considering the matter from the standpoint of the successful establishment and permanent operation of an independent and well rounded government-owned electric distribution system and the general civic, social and industrial planning and development of the Tennessee Valley region as a whole.

27. The TVA power policy was not designed or limited with a view to the marketing of the power produced and

available at Muscle Shoals. TVA did not propose to restrict new power installations either principally or primarily to governmental use, or propose to defer hydro-electric emplacements or installations until after some definite government uses had been planned or estimated to which the power production could be fairly related. Additional power installation was considered by the Board to be related rather to the question of power market and regional development and the ability of TVA to make further commercial sales of power or the effect on its power market of large blocks of power rather than to any estimated, rational or considered requirement for governmental use.

28. The Board in formulating or developing the power program or any of the steps in the program was not limiting its scope to any given desired generator capacity or capacity based on any estimate of requirements for governmental use, nor was it contracting for the provisional use of any power generated over and above governmental requirements in subordination to some supposed dominant or primary governmental use. In formulating and going forward with the power policy the Board was considering that policy as a permanent and independent commercial function.

29. The Board of Directors was unwilling to proceed with the construction of Wheeler Dam and to charge the cost thereof to power development (until ordered by the President to proceed with the dam at the cost of TVA), on account of the fact that it was not considered desirable to create an additional block of power by generation at Wheeler Dam at that time. This conception stated by the Power Director Lilienthal in his report to

the Board of September 18, 1933, was accepted by the Board as expressing its position in the matter.

30. At its meeting on July 30, 1933, the Board considered the following matters, among others:

> "Policies concerned with the power project were discussed. The question arose as to whether friendly attempts should be made to buy out power companies or whether the Authority should refuse to deal with them. It was suggested that the views of President Roosevelt and Senator Norris be obtained on this point.
>
> "Arthur E. Morgan proposed that an area be delimited roughly equal in size and corresponding in many respects to the Tennessee River drainage basin, in which the Tennessee Valley Authority might buy up the private power company properties. Under this proposal the Authority would have a clear field in which to operate.
>
> "It was suggested that a study be made of this proposal and of the cost involved. David E. Lilienthal was authorized to make such investigation and to employ such help as is needed for this and other power studies to be made by him. * * *
>
> "The Aurora power project, which comes before the Federal Power Commission for decision August 17, was discussed. Arthur E. Morgan suggested that it might be well for the Tennessee Valley Authority to condemn the Aurora and Hiwassee sites, as well as all other sites located by the Army Engineers, in order that the Tennessee Valley Authority would have control of future power developments in the area."

31. The testimony indicates that there are 149 of such power sites on the Tennessee and tributaries, with a potential output of 25 billion kilowatt hours of prime

power annually, aided by a relatively small steam capacity.

32. From the outset, TVA has considered that its power service, to the extent undertaken, must be the equivalent of existing utility service and must have the same characteristics and stability, including back-up or stand-by facilities, and interchanges with neighboring systems now common with existing systems and already fully practiced in the area. None of the contracts in evidence for sale of power by the purchaser reserved the right of termination except for breach.

33. Commercial sale of the power for profit under a power policy or program as shown by the evidence in this case necessarily requires a commitment for continuous availability, for long periods.

34. At the time this power policy was adopted TVA had not formulated any program for use of nitrate plant or for national defense or for the manufacture or method of disposing of fertilizer, or made any estimates to determine what was to be primary or requisite governmental use of power and what was to be a disposable commercial "surplus."

35. The Court finds that there would be no substantial excess or "surplus" electricity over and above the actual current requirements for governmental uses if the generating equipment were not operated.

36. The sale of electricity in the market and the operation of the generating equipment are functions that are physically distinct and separate from the plant equipment or capacity for production. Such sale is personal service within the discretion and control of the seller.

37. Under date of August 25, 1933, TVA announced its power policy, indicating both the initial stage of its development and certain later steps originally determined upon. This power policy is set out as Exhibit No. 3 to the bill of complaint. The same text appears at various points in the documents in evidence and was reiterated from time to time by TVA in public releases and reports. This power policy had not been rescinded or abandoned or modified at the time of submission of this cause.

38. The Muscle Shoals plants, including the Sheffield steam plant and the 8 hydro-electric units installed at Wilson Dam, were authorized for war purposes by Section 124 of the National Defense Act of 1916 in anticipation of participation in the great war. The original conception was for the use of Nitrate Plant No. 1 employing the Haber process and Plant No. 2 employing the cyanamide process for the fixation or manufacture of nitrogen and its subsequent conversion into ammonium nitrate for explosives. Plant No. 1 was completed but was never practicable, due to the lack of knowledge of the Haber process. Plant No. 2 successfully developed calcium cyanamide from a manufacturing standpoint but due to the availability of ammonium nitrate as a result of commercial development of by-product or synthetic processes, the commercial or peace-time manufacture of calcium cyanamide at Nitrate Plant No. 2 is considered uneconomical and undesirable and is not proposed or suggested by either the War Department or the TVA. The Court further finds, however, that the plant with the aid of electric power furnished by Wilson Dam and the Sheffield steam plant can be operated to produce annually 110,000 tons of ammonium nitrate by the cyanamide

process and that the present plans of the War Department count upon that plant to supply that amount annually in the event of a major war.

39. Separate units at Nitrate Plant No. 2 not connected with the twelve electric furnaces originally installed for the production of calcium cyanamide are capable of and fairly adapted to the production of 110,000 tons of ammonium nitrate or nitric acid by the oxidation of synthetic ammonia now commercially available in large quantities.

40. The existence of these facilities which make available large quantities of nitrogenous war materials by use of either the nitrogen fixing process or the oxidation of synthetic ammonia is a valuable national defense asset.

41. If it should be determined to produce the necessary nitrogenous war materials by the oxidation process rather than by the original cyanamide process the electric furnaces would be available for other war uses. Without substantial alteration they could be used to produce substantial quantities of certain specific war materials of which there were shortages in the world war.

42. The Court finds as a fact that there is no intention or plan to use the nitrate plants or the steam plant and hydro-electric units installed at Wilson Dam and the Sheffield steam plant to operate the Muscle Shoals properties for the production of war materials in time of peace, but that the maintenance of said properties in operating condition and the assurance of an abundant supply of electric energy in the event of war, constitute national defense assets.

43. The Court finds as a fact that the commercial sale of power generated at the steam plant or at Wilson Dam is not essential or reasonably required for the maintenance of those units in reserve or stand-by condition, but that such sale will result in obtaining revenues that may be used for any governmental purpose.

44. Two of the electric furnaces at Nitrate Plant No. 2 are adapted to produce phosphoric acid for phosphatic fertilizer. The other ten furnaces could be easily adapted to such purpose. Within a short period of time concentrators could be attached which would allow the daily production in each of these furnaces of approximately 40 tons of white phosphorus which is a "critical" war material.

45. White phosphorus was commonly used in the World War as a smoke screen and wounding weapon. Its use increased rapidly from the time of its initial utilization in the World War until the extent of its use was limited only by its availability.

46. Present plans of the War Department call for the availability of a large supply of white phosphorus for war use.

47. The availability of a substantial quantity of white phosphorus by the use of the electric furnaces at Nitrate Plant No. 2 is of substantial value to national defense.

48. The availability of the electric furnaces at Nitrate Plant No. 2 for the production of various war materials in war time listed as either "critical" or "strategic," when shortages in any or all of those materials occur, is a valuable national defense asset.

49. An analysis of the prime capacity at Muscle Shoals,

with the facilities now under construction, discloses the following state of facts as to the electric power available for use or distribution:

Prime Power Available From Wilson, Wheeler and Norris Dams and Governmental Uses.

50. **Prime Power at Wilson.**

Wilson Dam, without other interconnected power developments on the Tennessee River, will provide 50,000 KW of continuous capacity.

51. **Wilson Dam, interconnected with Norris.**

The continuous capacity of Wilson Dam will become 90,000 KW by the release of waters from Norris. Norris and Wilson, interconnected and operated in coordination, will provide 163,000 KW of continuous capacity. Hence, Norris adds 73,000 KW.

52. **Wilson, Wheeler and Norris Dams.**

Wheeler will increase the firm capacity at Wilson from 90,000 KW to 97,000 KW. The continuous capacity of the three plants, with Pickwick built, is 202,000 KW. This figure is obtained by adding 7,000 KW at Wilson to the 163,000 KW for Wilson and Norris in combination, and 32,000 KW installed capacity at Wheeler.

The 202,000 KW of continuous capacity is without the benefit of Sheffield steam plant.

If the continuous capacity of 202,000 KW is operated at a 50% load factor, the approximate load factor of the region, which represents the practical load or demand, there will be an equivalent of 404,000 KW, and there is not at the present enough installed capacity to carry such a load. At least 300,000 KW would be available at the outset at 50% load factor, which, multiplied by 4380 hours

would produce 1,314,000,000 KWH per year of prime power available.

Since the continuous capacity at Wilson, Wheeler, and Norris is 202,000 KW, it follows that, if used every hour in the year, there will be generated 1,770,000,000 KWH annually.

The foregoing is with reference to Wilson (8 generators), Wheeler (1 generator), Norris (2 generators), and with Pickwick back storage (no generator), without steam plant No. 2 to bring up prime power. With the seven dam program this capacity would be correspondingly enlarged and with complete hydro-development of the river the prime power would be still further expanded, and so on to the 149 potential sites and 25 billion KWH reported by the Corps of Engineers.

53. **Sheffield Steam.**

Sheffield steam plant, operated approximately 5 months during low water season, will prime Wilson to 90,000 KW; and the steam plant would be turning out at least 40,000 KW at the time Wilson was releasing 50,000 KW.

The testimony does not indicate that 90,000 is the limit of Wilson and Sheffield steam plant operated in combination. The generation of 350,000,000 KWH obtained by multiplying 40,000 KW (steam plant) by 8760 hours per year, is not to be taken as the total available from the Sheffield steam plant, inasmuch as higher stream flows at times other than low water season, will provide a considerable portion of this generation during the low flow year and a very large part during a year of average flow.

54. **Governmental Usage at Muscle Shoals.**

From Almon Exhibit No. 97, by subtracting the KWH

sold from the KWH generated, is obtained the difference which must be equal to the uses of the Government in the Wilson Dam power house, for lighting the houses and reservation, for pumping water, for operating machine shops and navigations locks, for supplying various losses, and for other miscellaneous uses incidental to Government activities at Muscle Shoals. The tabulation is as follows:

1926	6,750,300 KWH
1927	8,584,500
1928	5,237,800
1929	5,860,600
1930	6,859,200
1931	6,179,400
1932	6,019,000
1933	7,018,300

Almon Exhibit No. 97 does not indicate governmental uses in 1934, but these are given in the testimony. It may be assumed that such uses in 1934 included requirements at Muscle Shoals, construction energy for Wheeler and Norris, and power sold in proprietary utility service, exclusive of deliveries to the Commonwealth & Southern companies.

From the above tabluation covering the years 1926 through 1933 7,000,000 KWH may be taken as a representative figure for Governmental uses at Wilson alone, including requirements of lockage and other purposes before enumerated, without expansion of plant use, dealt with below.

During the past eight years the power required for the locks at Wilson Dam averaged 104,090 KWH per year. The ultimate requirements for lockage at Wheeler and Wilson are estimated at 430,000 KWH per year. These amounts of energy are so small in relation to the total

output for all uses, that variations for the purpose of estimating may be disregarded.

55. **Governmental Usage at Wheeler and Norris.**

There is no testimony analyzing the above mentioned figure of 7,000,000 KWH of government use. Inasmuch as the combined capacities at Norris and Wheeler are less than the installed capacity at Wilson, and as the Muscle Shoals reservation is of considerable size, including nitrate and fertilizer plants which do not appear to be contemplated at Norris and Wheeler, the usage at Wheeler and Norris may for this finding be safely assumed to be in the order of the requirements at Muscle Shoals, namely, 7,000,000 KWH.

56. **Government Uses for Construction Purposes.**

In 1934 approximately 6,000,000 KWH were required at Wheeler and 13,000,000 KWH at Norris. This latter figure includes transmission losses and service to the Town of Norris.

The testimony indicates that two other dams, one of a storage type and one on the main river, will be presently developed, following the completion of Wheeler and Norris. It is assumed that such construction activities will consume approximately the same amount of power as that presented in the testimony relative to Wheeler and Norris. However, on completion of construction work, the entire amount so allocated will be released for other uses, and as power for construction purposes is readily available at publicly regulated prices, it is not assumed or inferred that this temporary demand need be elaborated or considered as part of any fixed possibility of government use.

57. **Estimates of Prime Power for Governmental Usage.**

This is estimated at a capacity of 6,250 KW, determined by applying a 60% load factor to the 33,000,000 KWH above described.

58. **Power Requirements for Fertilizer Production.**

It is estimated that 630,000,000 KWH would be required for the production of 210,000 tons of 43% to 45% super phosphate, and that 20,000 tons of super phosphate can be produced annually from each furnace. Dividing 630,000,000 KWH by 210,000 tons, the result is 3,000 KWH per ton required for the production of super phosphate. Since each furnace has a capacity of 20,000 tons per year, 60,000,000 KWH would be the annual energy consumption per furnace.

There are 12 furnaces in Nitrate Plant No. 2, each having a capacity of 8,300 KW. Complete operation of Nitrate Plant No. 2 for the production of sodium nitrate would require 700,000,000 to 800,000,000 KWH per year, and 80,000 to 90,000 KW of capacity.

However, the testimony indicates that sodium nitrate will not be made at this plant, which is built to operate on the cyanamid process, because of the large capacity now available in the United States by other and more economical processes and that the plant is, therefore, obsolete except for possible revival in the actual course of war. This is the conclusion announced in the last annual report of the Secretary of War. The possible use for present purposes, as testified (which are general and indefinite in character, due to lack of any definite formulation of plans beyond the experimental stage) will apparently be limited to the production of phosphoric acid in the electric furnaces at this plant; on the hypothesis that

such furnaces may be rebuilt and converted into furnaces for production of phosphoric acid instead of carbide; carbide being the element of material into which the nitrogen is fixed in connection with the cyanamid process.

While there is no testimony as to the number of hours per year a furnace may operate, a figure of 8,000 may be assumed to represent a year's operating cycle. Therefore, to consume 60,000,000 kwh a demand of 7,500 kw per furnace will prevail. It follows, therefore, that the 12 furnaces in Nitrate Plant No. 2 would consume 90,000 kw of capacity.

59. **Additional Phosphate Furnaces.**

There are two experimental furnaces, converted for the production of phosphoric acid, in operation at present. Another two furnaces are considered.

This is conjectural and experimental and along with the entire erosion and fertilizer plan is indefinite and conjectural under the testimony.

60. **Production of 210,000 tons of Super Phosphate.**

If 210,000 tons of super phosphate, requiring an estimated 630,000,000 kwh are to be produced, it may be concluded that since each furnace will make 20,000 tons per year, 10½ furnaces or, say, 11 furnaces, will be required in continuous operation. Of course, furnace repairs, particularly with processes admitted to be largely developmental or experimental, are necessary, and probably the equivalent of one furnace out of twelve will be out of commission throughout the year. It seems reasonable to assume that 210,000 tons is the entire capacity of Nitrate Plant No. 2.

Since the operation of four furnaces has been accounted for in the previous computations, there may be added for

the purposes of a summary seven furnaces; and since each requires 7,500 kw, the demand will be 52,500 kw. There has been previously accounted for 240,000,000 kwh for the four furnaces, and the difference between this figure and 630,000,000 will leave a balance of 390,000,000 kwh for energy requirements of the additional furnace operation.

61. **Secondary Energy for Furnace Operation.**

In reference to the report of the Coolidge Commission for Muscle Shoals Inquiry, appointed March 26, 1925, it is indicated that secondary power may be used for fertilizer production. It is a matter of common knowledge that secondary power is particularly adaptable for use in electric furnace operations.

62. The foregoing analysis may be summarized as follows:

Summary

Prime Capacity—TVA Developments Less Estimated Governmental Uses, Projected at Time of Completion of Projects Under Construction February, 1935.

	Prime Capacity at 50% L. F. kw.	Annual Prime Output (Million kwh)
1. Wilson—Wheeler—Norris	300,000	1,770
2. Sheffield Steam	40,000	350
3. Total Prime Capacity.....	340,000	2,120
4. Governmental Uses		
a. At Muscle Shoals.....		7
b. At Wheeler and Norris....		7
c. Construction—2 dams in progress		19
d. Totals	6,250	33
5. Present—2 Furnaces	15,000	120
6. Total all Government Uses.....	21,250	153
7. Balance (12.8 times total Gov't. Use)	318,750	1,967
8. Add two furnaces in 1935.....	15,000	120
9. Balance—Prime Power (6.7 times total gov't use).....	303,750	1,847

If all Nitrate Plant No. 2 furnace capacity should be operated for production of super phosphate, the following items result:

10. Add eight furnaces.....	52,500	390
11. Balance Prime Power (2.2 times total governmental use)	251,250	1,457

Above estimates are for a low flow year, and assume that the indicated fertilizer operations will be allocated prime power. A normal flow year will provide a greater supply of power, and if furnaces are operated on secondary energy, the balance of surplus prime power would be:

12. Total Prime Capacity.....	340,000	2,120
Less Gov't. Uses.....	6,250	33
Balance Prime Power (63.2 times gov't. use).....	333,750	2,087

63. At the time this suit was filed TVA was actively developing a market for power, had announced that it had made market commitments for the full amount of power available at Muscle Shoals and could enter into no further commitments until Norris or Wheeler is completed.

64. The following additional characteristics of the proposed TVA system are shown by the evidence:

The power policy mentioned above included two geographical or territorial aspects, an initial service area (being that roughly included in the thirty counties—45,000 customers and approximately 700,000 population) proposed to be occupied or served by the TVA system according to its contracts (some of which contracts have since expired) outstanding at the time of the filing of the bill in this case, described below, plus the population and area along the route of the Wilson-Norris transmission line; and a second or later stage which was intended, as stated in Section 8 of the policy, to include

"roughly, the drainage area of the Tennessee River in Kentucky, Alabama, Georgia, and North Carolina, and that part of Tennessee which lies east of the west margin of the Tennessee drainage area."

This area would embrace approximately 42,000 square miles, with a population of 2,000,000 as estimated in TVA releases.

For the immediate or initial power system, the power policy stated that the system should take in a city of substantial size, such as Knoxville or Chattanooga, and in the second stage at least one city of more than 250,000 population, such as Birmingham, Memphis, Atlanta or Louisville. When the original bill was filed, the purchase by TVA of the system in Knoxville had been contracted for and the minutes for September 18, 1934 (Plaintiffs' Exhibit 41-i) contain reference to Lilienthal's report as to his negotiations with Memphis, which Chairman Morgan testified could be logically reached from Pickwick Dam.

65. The policy disclaimed limitation of the proposed power system (either initially or at the later stage contemplated) to the areas thus indicated if, in the discretion of the TVA, the public interest should call for extension, "or if the privately owned utilities in the area do not cooperate in the working out of the program."

66. The policy stated that "nothing in the procedure here adopted is to be construed in any sense a commitment against the Authority's power operations outside the area selected, if the above conditions of the public interest require." High electric rates, that is, rates high in the opinion of TVA, would constitute ground for con-

sidering extension of TVA service, as would "absence of public regulation to protect the public interest."

67. The TVA policy contemplates full corporate discretion by TVA in developing, executing and extending its electric system and service within transmission limits.

68. This policy contemplated service utility in type and covered not only generation but transmission and distribution (preferably through public or non-profit agencies, if available) both wholesale and retail. That is, moreover, implicit in both the January 4 contract and the now terminated August 9th contract.

69. The conception was to establish an independent network comparable in all respects with the electric utility system serving the area, with which TVA sought to establish interchange arrangements, both as outlets for its own power and to use existing systems as a stand-by or back-up service.

70. Among the objects and purposes intended to be accomplished by TVA by the electricity program are the following:

(a) To establish what has come to be nationally known as a power yardstick because of the wide discussion of the conception since its use by the present Chief Executive in the Presidential campaign of 1932, meaning a test of utility operations conducted by the government for the purpose of determining the reasonable cost of generation, transmission and distribution of electric energy with a view to its use by the public and by public authority in determining, between the advantages of public and private ownership, and as a test for measuring the reasonableness of privately owned system utility rates. This yardstick function was stated and continuously

recognized as an objective of the TVA operations both by the minutes of the corporation and in the public releases circulated by it, as well as by coordinate federal agencies of the Administration and is now, due to the extraordinary publicity given the TVA power projects, a matter of common understanding in this area as one of the functions of the TVA.

(b) A further objective is that the functioning of the TVA power program will supplement state regulation of public utilities, on the theory that regulation by the State and by agencies established under State laws has been inadequate and unsatisfactory.

(c) A third function of the program is to encourage public ownership of utilities within the area, to function under long term contracts for the supply of their power by TVA.

A similar objective is the promotion of public ownership and operation of electric utility distribution systems by cooperative or mutual associations intended to operate on a non-profit basis, with the aid of TVA where deemed necessary by it. In the case of Alcorn County and Pontotoc Associations, TVA has sold the property to the Associations.

The local distributing agencies described above are uniformly controlled as to operations by contracts with TVA by which the re-sale or retail rates are determined, the accounts are prescribed and controlled and earnings, reserves and surplus are disposed of as determined by stipulation in the contracts. The agencies will depend at the outset upon TVA for energy upon the withdrawal of other utilities from the competitive field. Forms of these contracts were set out in the statement of the evidence.

(d) A further purpose and objective is to promote rural electrification and to prefer rural use of electricity and domestic use, both urban and rural, over

industrial or commercial use and, where deemed necessary by TVA, to place a burden on the industrial rate structure, all as determined in the discretion of the TVA.

71. The contracts in evidence entered into by TVA with municipalities tangibly reflect these objectives:

Further direct objectives of the power program are:

(e) To earn a profit in order to reimburse the United States Treasury for the cost of the high dam program.

(f) The produce revenue in order to "round out the system."

(g) Social betterment and general welfare of the Tennessee Valley; and

(h) To promote use of electricity.

(i) To prevent waste of national resources in water power.

72. In finding a market and in building up its independent network, TVA preferred to purchase by negotiation, or to have municipalities purchase existing utility systems. If the utilities desired by TVA would not sell to TVA on terms acceptable to TVA, or to proposed municipal customers of TVA, the latter stands ready to assist such towns in obtaining funds for constructing competitive facilities, under contract to purchase TVA power.

73. It is found by the Court that utility service in the area, that service equivalent to utility service and that long term contracts for the service by the government of the type, character and extent of the TVA contracts dis-

closed by the evidence in this case have no direct, necessary or reasonable relation to any governmental function.

74. At the time the bill of complaint was filed the operating properties and utility service areas taken over or proposed to be taken over by TVA included the following:

System contracted to be taken over	No. of Counties in area served	Population of counties	No. of direct customers
Miss. Power Co.....	10	184,640	4,000
Ala. Power Co.....	6	193,423	10,000
Tenn. Elec. Power Co...	9	86,388	2,500
Tenn. Pub. Serv. Co.....	5	227,442	26,000
	50	691,893	43,200

75. At the time suit was filed the Northeast Mississippi properties acquired from Mississippi Power Company under the contract of January 4, 1934, were being operated by TVA and rural lines were in process of extension by TVA in Mississippi and Alabama.

76. The following are certain characteristics of the service, lines and properties proposed to be acquired from Alabama Power Company and certain consequences reasonably to be anticipated from the transfer:

77. Under the contract of January 4, 1934, TVA would acquire various facilities in an area in northwest Alabama of about three thousand five hundred square miles owned and operated by the Power Company for serving rural lines, small communities, wholesale power customers and fourteen urban distributing systems owned and operated by the Power Company and serving ap-

proximately 10,000 customers, in the counties of Lauderdale, Colbert, Lawrence, Limestone, Morgan, north half of Franklin and a fraction of Cullman (all as shown on Exhibit "B" of the January 4th contract and Plaintiffs' Exhibit No. 46 in this case), in addition to the transmission line by which the Power Company supplied the requirements of the municipal system owned and operated by the City of Athens. These facilities or services had the following characteristics:

(a) A total of 785 customers was being served by the rural distribution systems of Alabama Power Company in the counties of Lauderdale, Colbert, Lawrence, Limestone, Morgan, Franklin and Cullman, which consisted of 193 miles of 11,000, 6,900 and 2,300 volt lines, and the following distribution systems were served from rural lines in the following small communities; some incorporated and some not incorporated; namely: Barton, Hovater, Alexander, Wheeler, Hillsboro (incorporated), Trinity (incorporated), Moulton Heights, Flint, Eva, Fairview, Mooresville (incorporated), Greenbrier, Tanner, Capshaw, Elkmont (incorporated), Ardmore (incorporated), Weeden Heights and Killen, Center Star, Lexington, Anderson and Rogersville (incorporated).

(b) The Mississippi Power Company was being served by Alabama Power Company at a point on the Alabama-Mississippi line, marked No. 27 on the contract of January 4, 1934, (Plaintiffs' Exhibit No. 31), and at a point on the Gorgas-West Point line.

(c) TVA, by paragraph 5 of the January 4, 1934, contract, would have acquired the low tension transmission lines and substations supplying electricity to to the urban distribution systems of the Alabama Power Company in the counties of Lauderdale, Colbert, Lawrence, Limestone, Franklin, Morgan and a fraction of Cullman, in Alabama. Whether the re-

spective municipalities purchased the distribution systems in such towns from the Alabama Power Company or not, TVA would also acquire the right as against the Alabama Power Company to supply electricity to such municipalities or their inhabitants in competition with the Power Company unless the Power Company should sell the systems, viz:

> Decatur, Hartselle, Russellville, Courtland, Leighton, Cherokee, Falkville, Town Creek, Sheffield, Tuscumbia, Florence, Belle Mina, Moulton, Austinville, Athens and Red Bay.

By supplemental agreement evidence by telegrams between David E. Lilienthal and W. L. Willkie, dated May 24, 1934, and May 25, 1934, the Alabama Power Company agreed to transfer to TVA, the distribution systems serving the municipality of Belle Mina and other distribution facilities in Limestone County.

(d) By the acquisition by TVA of the 44 KV lines under paragraph 5 of the January 4, 1934, contract, the Alabama Power Company would be left without facilities for supplying electricity to the communities and municipalities in the area in the contract. In order to serve these towns, after yielding the transmission lines serving them to TVA, it would be necessary for the Alabama Power Company to construct additional lines from its systems or other facilities. Alabama Power Company would in such case have to obtain a certificate of convenience and necessity from the Alabama Public Service Commission to re-acquire or construct such lines or facilities or to resume utility service in the area.

By the terms of the contract, Alabama Power Company agreed that during the period of the contract it would not sell electric energy to any municipality, corporation, partnership, association or individual in any portion of such counties in which these properties had been transferred out of Alabama Power

Company in accordance with the contract or in which the company at the time of entering into the contract did not own such properties.

Under paragraph 4 of the January 4, 1934, contract, the Power Companies were required to include in any conveyance not only the physical property, systems and rights of way, but also all machinery, equipment, tolls and working supplies set forth in the respective exhibits, and all franchises, contract and going business relating to the use of any of said properties, without extra charge, and also were required to transfer or secure the transfer of said franchises, contract and going business, and to transfer said property with all customers attached so far as they were able.

78. The TVA plan as conceived and in process of execution contemplates complete and exclusive control and jurisdiction over all power sites on the Tennessee River and tributaries.

79. TVA conceives it necessary, in order to obtain a market for TVA power, to acquire existing utility systems, including distribution as well as transmission facilities. Its preference as to the retailing is that the municipalities should be encouraged to acquire distribution systems and cooperative or mutual systems the rural lines, both to serve as an outlet for TVA power under the TVA wholesale contract.

80. The following facts have accompanied the development of the TVA power program:

(a) The Power Director at two meetings of the Board proposed the adoption of a "technique" for valuing and acquiring existing utility systems. The current budget request for fiscal 1936 submitted to

Congress in January, 1935, sets up $5,000,000 for the acquisition of additional transmission systems and negotiations to the extent of part of this amount were under way.

(b) Beginning shortly after the negotiation of the contract of January 4, with Commonwealth & Southern and its named subsidiaries, TVA became active in negotiating for the purchase of the properties of the Tennessee Public Service Company, operating in Knoxville (Knox County and four adjoining counties in the Knoxville area). These negotiations were accompanied, as in the case of the January 4 contract, by a commitment from PWA (in furtherance of the TVA program) for a loan to Knoxville for the competitive duplication of the existing system under long time contract to purchase TVA power. The negotiation resulted in a final agreement on July 26, 1934, with the Tennessee Public Service Company. This agreement was outstanding and in process of execution at the time of the filing of the bill of complaint, but has since expired and been terminated.

(c) The contract of August 9 between Alabama Power Company and TVA, calling for the transfer to the latter of fourteen urban distribution systems, was outstanding at the time suit was instituted, notice of termination by TVA having been served on Alabama Power Company on January 24, 1935.

This transfer of its fourteen urban systems by Alabama Power Company was implicit in the agreement of January 4, 1934. While reserved from the transmission systems and rural distribution systems definitely to be conveyed by the contract of January 4, 1934, Section 5 of the agreement of January 4, (Exhibit No. 5 to the Bill of Complaint) provided that Alabama Power Company shall convey the reserved distribution systems listed in Exhibit "B" to the respective municipalities when the Power Company had agreed

with the municipalities on the price. The Power Company convenanted to try to reach an agreement, TVA assisting. If the reserved systems should not be sold to the respective municipalities within three months, TVA reserved the right to serve such municipalities direct. Loans from PWA had either been allotted or were potentially available.

81. It is a matter of judicial notice in the area of this judicial division that the municipalities in question are in a serious financial situation, due to the shrinkage in revenues from recession in ad valorem tax values and because of the high ratio of municipal indebtedness to property values and revenue. Two of the towns, Florence and Tuscumbia, are in receivership in this court. Receivership proceedings by general creditor's bill is pending against the City of Decatur. It is a matter of common knowledge that the towns have no resources with which to pay in cash or make substantial payment in cash, for electric distribution systems. The transmission lines covered by the contract of January 4th are the only existing means of serving the fourteen towns.

82. When there was delay in transferring the properties TVA rescinded and at or immediately before rescission effectively used its efforts to expedite the PWA loans to the respective towns.

83. There was at the time of the trial of this cause and at the time of submission, no recession by TVA from its original intent to go forward with the plan of serving the area covered by the contract of January 4, 1934, preferably at wholesale under long term contracts controlling rates, accounting and the disposition of earnings and surplus.

84. The utility properties taken over by TVA from the Mississippi Power Company were at the time of the filing of the bill, being operated in their entirety directly by TVA or by organizations promoted by TVA to take over the retailing, under TVA contracts as above stated.

85. The evidence shows that all forms of utility service were involved in the Mississippi operations taken over or contracted for by TVA, including that of sales promotion.

86. The Court finds that said properties were not purchased for any governmental use.

87. The TVA budget justification announces that arrangements have been made to supply power to more than 50 municipalities.

88. TVA has formally adopted a fixed requirement for all city gate contracts for the service of municipal systems.

89. All of the electric properties and facilities covered by the contract of January 4, 1934, as well as the Athens distribution system covered by the Lilienthal-Willkie letters dated May 24 and May 25, 1934 (Pl. Ex. 23), as well as the urban distribution systems covered by the contract of August 9, 1934, were used and useful for and were contracted for by TVA for the purpose of providing a market for power through and by means of the operation of the properties in the rendition of utility service and as a substantial means and part in the power program as herein outlined. They were contracted for by TVA for the purpose of continuing and enlarging the utility service for which they were used by the respective power companies.

90. TVA intends to interconnect all of its power installa-

tions when and as constructed and to operate the same as an integrated, inter-connected and independent system, and is now constructing the Wilson-Wheeler-Norris line.

91. The proposed sale in the commercial market of the power from those plants and from this pool by means of the properties involved in this suit is not the sale of a legitimate excess or surplus and is not lawful governmental use.

92. The War Department, because of the stated desirability of holding the Muscle Shoals power plants free for other governmental disposition, has declined offers of the power companies for the lease of the power facilities, one of the offers being a rental of $2,200,000 annually.

93. The Alabama Power Company and the Commonwealth & Southern system subsidiaries as a whole have a surplus of capacity at the present time. So far as the Alabama Power Company is concerned it was stipulated at the hearing that the facts averred in Section 4 of the bill of complaint were true, including the averment that the company has an actual installed capacity of 54% in excess of its present demand.

94. The evidence fairly supports the conclusion that if and to the extent that Tennessee Valley Authority shall market any part of the power produced at Government dams, it must take an existing or potential market from existing utilities.

95. The Alabama Power Company within the area proposed to be ceded to TVA by the contract of January 4, 1934, is subject to the jurisdiction of the Alabama Public Service Commission as to extension of and adequacy of service and facilities. No complaints or proceedings are pending against it as to rates or service.

Electric Home and Farm Authority, Inc.

96. The initial conception of this organization is reflected in successive references in the minutes of TVA to the necessity for reducing the cost of electric applicances in order to build up the electric load in support of the TVA program and the market for power in the TVA area. The concept of a greater nation-wide use of electric appliances is also indicated, but so far as TVA is concerned, it appears to be limited to the Tennessee Valley States. At a number of points recorded in the minutes is the recommendation of the Power Director that it appears desirable to request Congress to enlarge the power of the Tennessee Valley Authority so as to authorize a promotional activity of this character.

97. This action was followed on December 19, 1933, by the President's Executive Order No. 6514, dated December 19, 1933, which is attached to the original bill of complaint as Exhibit No. 8. The charter of the corporation, organized pursuant to this Executive Order, is to be found in Plaintiffs' Exhibit No. 32. The corporate powers and purposes of this corporation include the following among other clauses practically unlimited in scope:

> To finance the purchase of electrical appliances and in general to carry on in connection with such financing a chattel mortgage-loan business; to engage in studies and experiments looking to the increased use of electricity; to manufacture and deal in electrical appliances; to lend money and guarantee obligations in general; to borrow money; to purchase and lease property; to carry on its business in any State, territory or foreign country.

98. All of the stock of the corporation was issued to

the United States or to the Directors of Tennessee Valley Authority for the account of the United States, in consideration of the payment of one million dollars, which was appropriated for that purpose by the Executive Order under color of Section 220 of the National Industrial Recovery Act, 48 Stat. 195, 15 U. S. C. 701.

99. This corporation was created and has been regarded throughout as an agency of the Tennessee Valley Authority in the promotion of its announced power program. This conclusion is supported by its uniform treatment by the directors, by the provisions of the minutes, by the expenditure of TVA and, in general, by the corporate transactions of the TVA.

100. There have been distributed 666,686 of the various EHFA circulars devised by Young & Rubicam, an advertising firm employed by TVA, posters and sales appeal literature, consisting of nine different forms, designed to promote sales of electrical appliances.

101 Section 19 of the contract of January 4, 1934, imposes upon the Alabama Power Company the obligation to cooperate with Tennessee Valley Authority and with EHFA in promoting the sale of electrical appliances. In the performance of this obligation under the contract of January 4, 1934, Alabama Power Company entered into the agency contract dated May 21, 1934, which is set out as Exhibit 10 to the bill of complaint. Certain facts as to performance under this contract are set out in Section 37 of the answer of Alabama Power Company filed herein and the facts thus stated in the answer were proven by the testimony.

102. The evidence establishes the fact that the Ala-

bama Power Company has full knowledge of the organization of EHFA and of the source of its funds.

103. EHFA designated an agent for service in Alabama. The activities by Alabama Power Company as agent for EHFA under the agency arrangement are as set forth in Section 37 of the Power Company's answer.

104. The operation of a commercial utility service by TVA and the wholesaling and retailing by TVA of electricity in the area served by the Alabama Power Company is not and will not be in aid of the regulation of navigation or national defense or other governmental function in so far as any plan, purpose or activity of the TVA or of the United States disclosed on this record would indicate.

105. For the purpose of actuating the locks and related uses, a turbine, integral with the lock itself, or small Diesel engine plant, or a combination of the two, capable of being installed at a fraction of the expense of the commercial units, would be adequate. In their design of the Wheeler lock, the Corps of Engineers made provision for an installation of this character and the opening or emplacement for that unit is in the lock now being constructed. There is a small installation of like character at Wilson Dam sufficient to operate the locks and all appurtenances, independent of the battery of turbo-generators and of the steam plant.

106. The Court finds that there is no physical or functional relation between the installation or non-installation of hydro-electric units (or the generation of energy thereat) in intentional excess of any capacity required for actuation of locks and dams and related purposes in or as

a part of navigation dams and the regulation of navigation. The commercial sale of power in time of peace to industries or to the public not engaging or proposing to engage in some process relating to national defense or governmental use has no relation to and is not in furtherance of national defense or other governmental use or function as shown on this record.

107. The Court finds on the evidence that an existing policy of the War Department in relation to national defense is substantial reliance on privately owned industry; that there is an effective national plan in process of active development and execution, with full cooperation from industry, for the adjustment or adaption of industry to prospective war requirements. An agency of the War Department to that end is functioning in the district served by the Alabama Power Company, with headquarters in Birmingham. Electricity is a source of energy of importance in war planning. The existing utility systems are important elements in that planning and in the prospective service of the public both for direct war operations and for the service of the civilian population in time of peace. No request has been made by the War Department upon the TVA to generate additional power or to engage in the commercial sale or distribution of power as to any energy existing at Muscle Shoals or any energy to be made available in the development of the program of TVA. The War Department has made no request upon TVA to plan for national defense or made any delegation of authority to TVA as to planning for National Defense. They have assumed that the Muscle Shoals plants would be available for national defense and have counted upon that.

108. A 30,000 KW steam-electric unit constructed by the United States at or in the vicinity of the Gorgas steam plant of the Alabama Power Company in the Warrior coal field and interconnected by transmission line between Gorgas and Muscle Shoals, was sold pursuant to the agreement under which they were constructed, by the United States to Alabama Power Company several years after their construction. The inter-connections between the surrounding utility systems and Muscle Shoals were installed as a result of request by the War Department, pending final or further action by Congress as to the Muscle Shoals plants. The sales of power made to the utility companies by the War Department were on a short time terminable basis. Pending further consideration of the development of the river, an application by a corporation representative of the Electric Bond & Share and Commonwealth & Southern groups, for a license to develop under the Federal Water Power Act and consistently with the recommendation of the Corps of Engineers, some eleven sites on the Tennessee and tributaries was dismissed by the Federal Power Commission in 1931.

109. The Federal Emergency Administration of Public Works, called PWA, functioning under Title II of the National Industrial Recovery Act, is co-operating with TVA in the matter of grants and loans of federal funds to municipalities. On inquiry by said Federal Emergency Administration of Public Works, TVA kept said PWA advised of all of the towns within the area proposed to be ceded by the contract of January 4th which, as a result of delay might conclude to go forward with the construction of their own systems. There was introduced in evidence representative proceedings by PWA as to these applications the resolutions as to the City of Decatur being

offered and received as typical. From this it appears as follows:

(a) PWA approved the loan and grant to the municipality for the reasons, among others, expressly stated in the resolution adopted by PWA and approved by the President, that the loan and grant would help provide a market for TVA power.

(b) The loan was approved subject to the conditions covered in a resolution or recommendation of the Electric Power Board of Review, established within PWA to consider matters involving complication, "competitive situations," and to review disapprovals by other divisions of loans for municipal electric systems. This resolution of the Electric Power Board of Review made plain that PWA contemplated destructive competition with the Alabama Power Company as a result of the loan and TVA electric power service. It pointed out its conclusion that the rates to the public to be charged as a result of this combination would be 60% less than Alabama Power Company rates, and that the latter could not, because of circumstances perhaps erroneously stated in the resolution but obviously correct as a matter of fact, institute competitive rates, and that the municipal system would accordingly draw to itself ultimately all of the business and force out the Alabama Power Company.

110. The following appears from the evidence:

(a) The telegram of the Administrator to the City of Florence (Plaintiffs' Exhibit 34-a), advising the City of Florence that the policy of the Public Works Administration was to support TVA and that PWA would advance no funds for expenditures inconsistent with TVA plans, but that the loan and grant would be held open pending TVA purchase of Alabama Power Company properties;

(b) Public releases by Lilienthal under date of July 17, 1934, indicating that PWA withheld or refrained from acting upon municipal applications while TVA negotiates for the purchase of utility systems within the municipality;

(c) Stipulations as to the testimony of the Federal Emergency Administrator of Public Works, viz:

"That the telegram from him to Mayor Lee Glenn, Florence, Alabama, dated July 11, 1934, was sent after a conference with David E. Lilienthal.

"That prior to November 1, 1933, David E. Lilienthal conferred with the administrator of Public Works, and that the Administrator expressed his willingness to consider in a cooperative manner applications for loans in the Tennessee Valley area for municipal electric systems where towns had entered into contracts for power with Tennessee Valley Authority.

"That from time to time after January 4, 1934, consideration and action on applications for loans from Alabama towns in the area covered by that contract were affected by advice from the Tennessee Valley Authority as to the existing status of negotiations for the purchase of such properties. Within the last few weeks, at about the time of the letter of David E. Lilienthal to the Alabama municipalities, consideration and action upon such application was expedited.

"That the Administrator of Public Works regards that part of the Tennessee Valley Authority program relating to the generation, transmission and sale of power as constituting a part of the general policy and program of the National Administration."

(d) The statement, in a letter of instruction sent to all state engineers by the Deputy Administrator of Public Works, that

"We are most anxious to set up around the country

sound publicly owned utilities as yardsticks to determine the principle of whether or not communities can satisfy themselves and give lowered rates for electricity."

It is a uniform provision, stated as a condition precedent, in the contracts between PWA and the defendant municipalities that the PWA would be under no obligation to make any loan or grant

If the Borrower shall not execute a valid contract, satisfactory to the Administrator, between the Borrower and the Tennessee Valley Authority under the terms of which the Tennessee Valley Authority will supply electrical energy to the Borrower."

111. Prior to the contract of January 4, 1934, Alabama Power Company served all of the municipal defendants and their citizens directly except the City of Athens, which owns and operates a municipal system, but which prior to the contract was served at wholesale by Alabama Power Company. Since the execution of the contract the City of Athens and TVA have entered into a contract by which TVA serves the City of Athens at wholesale under a contract for a twenty-year supply of the requirements of the municipality. That contract stipulates the re-sale rates which the City may charge, and also subjects the City to the standard provisions of the TVA contract as to its method of accounting and the use and disposition of earnings, surplus and reserves.

112. The Court finds that Alabama Power Company is ready and able to respond to any requirement of the public service imposed by law within the area covered by the contract of January 4, and that any assumption of utility service or its equivalent by TVA in the area will be competitive with Alabama Power Company, either directly

or, if the area is not at present reached and served by Alabama Power Company, will be competitive in tending to prevent its normal extension of service to the customer or area thus served by the TVA.

113. The TVA has not invited proposals for the lease of these steam-electric plants at Muscle Shoals or for lease of any of the hydro-electric plants at either Wilson Dam or at any of the dams under construction or proposed, or to lease the emplacements.

114. The proposed sale of properties involved in the contract of January 4, 1934, assuming that TVA is without lawful authority to take over these properties for proprietary operations or to acquire properties for competitive proprietary operations, would result in the loss of annual gross revenue to the Power Company from the operation of these properties of approximately $750,000.

115. The franchises, licenses and grants in the area which would be transferred or abandoned and lost by non-user as a result of the transfer, are elsewhere tabulated or referred to in the findings.

116. TVA has acquired or contracted for

(a) Steam stand-by plants and oil engine plants;

(b) Supply of power to be generated by other owners, such as the interconnections under the contract of January 4, 1934, and, in the case of the proposed acquisition (subsequently terminated) of Tennessee Public Service Company properties in the Knoxville area, a contract for purchase of power for a stated period from Carolina Power and Light Company.

117. The Court finds that the excerpts from the releases

published by TVA as set forth in Exhibits 4, 7, 9 and 11 to the bill of complaint were in fact included in public releases circulated by TVA.

118. The Court finds that there is no relation shown on the record between navigation, or erosion, or fertilizer production, or national defense on the one hand, and commercial and proprietary sale of power committed, produced, set apart and sold to the public by TVA at wholesale or retail on the other.

The Court makes the following additional findings of fact, requested by defendant Tennessee Valley Authority without consenting to the foregoing findings and without waiving its rights under its prior motion requesting other findings:

119. The sale of electric energy generated at Muscle Shoals in excess of the amount required for operating the locks and servicing Government properties will, if made at a price resulting in a net profit on the operation, result in obtaining revenue which may be applied in reimbursing to the United States a portion of the cost of the dams constructed, or to be constructed, in the Tennessee River and its tributaries, and the obtaining of such revenue is one of the stated purposes of the Tennessee Valley Authority in generating and selling such excess energy.

120. The present demand for electric energy in the territory serviced by the transmission lines that are the subject of the Alabama Power Company contract of January 4, 1934 can be supplied entirely by power presently available at Wilson Dam, without the necessity for any interconnection with any other dam or power plant. Such interconnection is proposed with all units and is now in process of construction.

121. The only high tension transmission lines leading to and from Wilson Dam, except those under construction by the Tennessee Valley Authority, are, at the present time, owned by the Alabama Power Company and affiliated companies, all of which were constructed under contract with the War Department.

122. The area within a radius of 150 miles from Wilson Dam is served exclusively, with the exception of a few municipal generating plants, by subsidiaries of the Commonwealth & Southern Corporation, and subsidiaries of the Electric Bond & Share Company, and by Tennessee Valley Authority.

123. Ninety-seven percent of the rural residents in the Tennessee Valley are without electric service of any kind. There are rural communities in the counties surrounding Wilson Dam now without such service which have petitioned to the Tennessee Valley Authority for service. In order for rural electric lines to be self-sustaining it is necessary to select them.

124. One of the transmission lines included in the contract of January 4, 1934, carries power from Wilson Dam across the state boundaries of Alabama into Mississippi and Tennessee. All of the transmission lines in suit are interconnected with the transmission system of the Alabama Power Company, which is an integral part of a network employed principally in the service of the Alabama Power Company's Alabama system with several interconnections for interstate transmission of electricity to or between utilities serving other states.

125. In order to obtain the maximum benefits for navigation and the control of flood waters in the Ten-

nessee Valley, it is essential that the construction of dams upon the Tennessee River and its tributaries should proceed in such a manner that those dams that are most necessary should be constructed first and at the most advantageous sites.

126. It is not practicable to expect construction in the immediate future by private interests in cooperation with the United States under the plan authorized by the Rivers and Harbors Act of 1930 alone, of sufficient high dams to provide for nine foot navigation of the Tennessee and maximum flood protection, throughout its entire extent.

127. At the time of the enactment of the Tennessee Valley Authority Act, there was no reasonable prospect that a comprehensive development of the Tennessee River and its tributaries for the combined purpose of navigation and flood control could be obtained in any other way except by the construction of dams by the United States Government, or some agency thereof.

128. The use of water in the reservoirs upon the Tennessee River and its tributaries for the generation of power or flood control may conflict with the use of that same water for navigation and vice versa, according to control exercised or reserved over the several functions.

129. In order to obtain the maximum benefit to navigation upon the Tennessee River, and the maximum reduction of destructive flood waters in the Tennessee and Mississippi River valleys by the construction of dams and the operation of reservoirs upon the Tennessee and its tributaries, close coordination in the operation of all of the various reservoirs involved is essential, and it is desirable that the water control at all dams, required for

such result be under or subject to one unified jurisdiction and control.

130. The problem of improving navigation upon the Tennessee River has been studied by the United States Army Engineers and considered by Congress for over one hundred years, and during the course of that time Congress has authorized many projects and made many appropriations, both for open channel improvements and canalization.

131. In 1918 Congress authorized the construction of Wilson Dam which provided a nine foot slack water development over the Muscle Shoals rapids and flooded out the then existing canal and locks which were inadequate. A high dam of this type was the only feasible means of eliminating this most serious obstruction to navigation.

132. Pursuant to Congressional authorization, a comprehensive survey of the Tennessee River and its tributaries with respect to navigation, flood control and power development was undertaken by the Corps of Engineers whose report is contained in House Document No. 328, 71st Congress, 2d Session. The recommendations contained in that report were adopted by Congress in the Rivers and Harbors Act of 1930.

1933. In its present condition, the Tennessee River is not adequately improved for commercial navigation and due to the numerous obstacles the traffic at the present time is much less than could be expected with a commercially navigable waterway. Substantial improvement in the navigation facilities will substantially increase the extent and value of such traffic.

134. The only feasible method of obtaining an adequate

navigation channel over the entire length of the Tennessee River is by means of a system of dams. This might be accomplished by a series of thirty-two low lift dams in addition to those already in the river, or by a series of seven high dams of the type of those being constructed by the Tennessee Valley Authority in the main stream, or a combination of the two. The high dam type of development will furnish navigation facilities superior to those that would be provided by the alternative low dams or by a combination of the two.

135. The completion of Norris Dam will improve navigation upon the Tennessee River and gives an increased navigable depth on certain of its tributaries.

136. The completion of Wheeler Dam will improve navigation upon the Tennessee River and certain of its tributaries.

137. The completion of Pickwick Landing Dam will improve navigation upon the Tennessee River and certain of its tributaries.

138. The three dams that are now being constructed by the Tennessee Valley Authority considered together will materially improve commercial navigation over sections of the Tennessee River and certain of its tributaries.

139. There is now, and was at the time of the passage of the Tennessee Valley Authority Act, a serious flood problem in the Tennessee Valley and particularly at the City of Chattanooga.

140. The flood problem in the Tennessee Valley cannot be adequately solved by means of levees or local protection works alone, and storage by means of reservoirs is essential to adequate flood control on the Tennessee.

141. The construction of Norris Dam will, if operated to that end, substantially reduce destructive flood waters in the Tennessee Valley generally, and particularly at the City of Chattanooga.

142. Both Wheeler and Pickwick Landing Dams, as being constructed, are valuable for flood control purposes in the Tennessee Valley.

143. There is now, and was at the time of the passage of the Tennessee Valley Authority Act, a serious flood problem in the Mississippi Valley, particularly in the lower river below Cairo.

144. The plan adopted by the Flood Control Act of 1928 for a levee system on the lower Mississippi supplemented by diversion flood ways, is not completely adequate for protection against flood damage and leaves considerable areas in the alluvial valley unprotected from floods.

145. The construction of Norris Dam, and high dams in the main stream of the Tennessee, such as Pickwick Landing and Wheeler, if manipulated to that end, will serve to decrease flood crests in the lower Mississippi River and will supplement the flood protection furnished by the levees and flood ways. The practical efficiency of such operation and the extent of the benefit is a matter of dispute.

146. In order to accomplish both the improvement of navigation upon the Tennessee River and any reduction of destructive flood waters in the Tennessee and Mississippi River Valleys by means of engineering works upon the Tennessee River and its tributaries, it is necessary to construct high dams such as Wheeler and Pickwick Landing in the main stream of the Tennessee River and storage

dams, such as Norris, upon the tributaries of the Tennessee River.

147. Expert opinions differ as to the amount of the reduction in flood stages on the lower Mississippi from the operation of such dams.

148. The extreme variation in stream flow, shown by the evidence to exist at Wilson Dam, results in a great variation in the amount of power available at that dam from time to time.

149. It is the presently announced plan of the Tennessee Valley Authority to install only two 50,000 KW generating units at Norris Dam when completed, and only one 32,000 KW generating unit at Wheeler Dam on the eight emplacements provided in that dam. The tentative plans of the United States Army Engineers for the construction of the Cove Creek Dam included the installation of three generators.

150. The presently announced plan of the Tennessee Valley Authority is to construct the Pickwick Landing Dam without installing any generating units upon its completion upon the six emplacements designed in that dam for generators.

151. As a result of the completion of the announced plan for construction and installation, the total amount of firm continuous power available at all of the dams, including the eight generators installed at Wilson Dam by the War Department, will be 202,000 KW, in addition to 60,000 KW at the steam-electric plant, which makes possible the generation of approximately 2,500,000,000 KWH of electric power annually, assuming a continuous or 100% load factor.

152. The storing of water in a reservoir storage dam of

the type of Norris Dam in flood seasons and the subsequent release of such waters in low flow seasons creates during a certain period of the year a large amount of potential water power.

153. The construction of high dams of the type of Wheeler and Pickwick in the main stream of the Tennessee River and the release through such dams of the ordinary river flow in all seasons of the year necessarily creates great amounts of potential water power.

154. It is not practicable to construct either storage dams upon the tributaries or high dams in the main stream without providing any emplacements or intakes and then, after construction, make provision in such dams for emplacements and intakes.

155. The estimated cost of Wheeler Dam as shown by the evidence as it is being constructed by the Tennessee Valley Authority with power house, eight emplacements for generators and one generating unit installed, is $29,548,000. The estimated approximate cost of a dam of the same height which would have the same value for navigation and flood control, without any facilities provided for the subsequent generation of power, is $24,654,000.

156. The estimated cost of Pickwick Dam as shown by the evidence as it is being constructed by the Tennessee Valley Authority, with power house and six emplacements for generators, is $22,000,000. The approximate cost of a dam of the same height which would have the same value for navigation and flood control, without any facilities provided for the subsequent generation of power, is $19,000,000.

157. The construction of high dams in the main stream of the Tennessee River, such as Wheeler and Pickwick Dams, and the construction of storage dams on the tributaries of the Tennessee, such as Norris Dam, makes possible, if operated to that end, the reduction of destructive flood waters in the Tennessee and Mississippi River Valleys, that would not be possible with low navigation dams and also makes possible the creation of more advantageous conditions for navigation than would be provided by low dams in the Tennessee River.

158. The cost of the construction of high dams such as Wheeler, Pickwick and Norris, can be partially reimbursed by converting the water power available at such dams into electricity and selling the same at a profit, sufficient to provide revenue in excess of all appropriate operating and capital charges.

159. The erosion of the soil which exists in the Tennessee drainage area, results in the silting of storage reservoirs and to some extent in the channels of the navigable streams. The extent or seriousness of the latter is a matter of difference of opinion.

160. The only feasible method of checking erosion is by means of forest or other vegetative cover; and the only substitute for forest cover that can be adapted to cultivated lands is the growth of cover crops.

161. Cover crops cannot be produced to best advantage upon the agricultural land in the Tennessee Valley without the addition of phosphorus to the soil to make up for the existing deficiency of this element in the Valley and generally throughout the country.

162. The Tennessee Valley Authority has been and is

engaged in the formulation of a program or a study for the control of erosion upon agricultural lands located in the Tennessee Valley based upon the effective use of phosphorus plant food in cropping systems designed to make possible the cultivation of the necessary cover crops. This program contemplates the manufacture of phosphatic fertilizers at Nitrate Plant No. 2, requiring the use of electric energy, and the distribution of such fertilizer to selected farmers in the Valley conditioned upon its use in the growth of crops providing protection to the soil. The plan up to date is limited to demonstration use. The details of its extension to include the owners of up to 7,000,000 acres of land is under consideration and has not been determined.

163. According to the testimony, the total annual requirement of fertilizer contemplated for this program is 210,000 tons of triple super-phosphate per year. In order to produce one ton of phosphorus 10,000 KW of electric energy will be required. The power consumption at Nitrate Plant No. 2, in order to meet this requirement for fertilizer, would require 630,000,000 KWH per year.

164. Sixty-eight per cent of the electric power generated at Wilson Dam by the Tennessee Valley Authority during 1934 has been used in operating the locks and serving other government properties.

165. The most necessary and desirable improvement in navigation upon the Tennessee River at the present time is that which will result from the completion of Wheeler and Pickwick dams, since they together will render navigable that section of the river between Pickwick Landing and Guntersville.

166. Any flood on the Tennessee River of similar height to that of 1927 has the effect of interfering with and interrupting commerce and trade, not only on the river itself, but at various points along the river, especially at Chattanooga. This includes interruption of interstate commerce along the highways and interference with terminals for interstate railroad transportation located at the City of Chattanooga.

The Court makes the following additional findings of fact requested by the defendants City of Florence and City of Decatur:

167. Florence, Sheffield, and Tuscumbia, Alabama, touch, practically, with their municipal boundaries, the government properties of U. S. Nitrate Plant No. 2 and Wilson Dam.

168. Decatur, Alabama, is about twenty-five miles from Wheeler Dam, and about forty miles from Wilson Dam.

169. No utility company has a franchise to operate in Florence, Sheffield, or Tuscumbia; Alabama Power Company's franchise having expired in those towns in 1932 and 1933. (See finding No. 23).

170. Alabama Power Company has a franchise to operate in Decatur, Alabama, until 1949.

171. Florence, Sheffield, and Tuscumbia are situated on the Tennessee River and have been concerned and active for many years prior to the Tennessee Valley Authority Act about procuring complete navigation on the Tennessee River and the securing of municipal distribution of electric power.

172. The United States through Tennessee Valley Au-

thority is now engaged in the generation of electric power at Wilson Dam in the Tennessee River. Such power is being used in the operation of Wilson Dam, in the operation of United States Nitrate Plant No. 2, in the lighting of government villages adjacent to said dam and said plant. Alabama Power Company has a transmission line coming from its system to the switch-board at Wilson Dam Power House. The sale of power by the United States to Alabama Power Company was provided for under contracts between the parties since the completion of said dam in 1926. The production of power at Wilson Dam and the sales made to Alabama Power Company for each year, beginning with the year 1926, have been as follows, to-wit:

Year	KWH Generated	KWH Sold
1926	439,379,300	432,629,000
1927	565,609,500	557,025,000
1928	222,096,800	216,859,000
1929	171,681,600	165,821,000
1930	306,119,200	299,260,000
1931	345,603,400	339,424,000
1932	286,638,000	280,619,000
1933	287,862,300	280,844,000

173. Power generated and sold at Wilson Dam by the United States for the years 1926-1933, inclusive, has been power not required for governmental use for the period named.

The Court was requested by Chemical Bank and Trust Company to make findings as to the offer of testimony made at the trial on behalf of Chemical Bank and Trust Company, but has not conceived that such findings are, in addition to the findings hereinabove set out, necessary to the disposition of the cause.

Conclusions of Law

(1) The Congress has no constitutional authority to authorize Tennessee Valley Authority or any other federal agency to undertake the operation, essentially permanent in character, of a utility system, for-profit, involving the generation, transmission and commercial distribution of electricity within State domain, having no reasonable relation to a lawful governmental use.

(2) The power program of Tennessee Valley Authority relating to the generation, transmission and commercial sale of electricity as shown by this record, substantially utility in type and permanent in its implications, is not related to any lawful governmental function and is beyond the power of Congress to authorize.

(3) If and to the extent that the Tennessee Valley Authority Act should be construed as authorizing Tennessee Valley Authority to operate an electric generating, transmission and commercial distribution system, of the character and type proposed and intended by Tennessee Valley Authority as shown on this record, such act would be beyond the power of Congress and void. It is, accordingly, unnecessary to determine whether the Act authorizes such operation by Tennessee Valley Authority or whether the Act, because of inclusion of illegal objectives, delegation of legislative power, legislative uncertainty or for other reason, is invalid.

(4) The Congress is without authority to authorize an agency of the government to bind itself or the government to a long term commercial servitude for the operation within State domain of an electric network involving generation, transmission and delivery of electricity essentially

proprietary and utility in type and having no relation to any lawful governmental function.

(5) The proposal or undertaking of TVA to bind or commit itself to operate the steam-electric or hydro-electric units at Muscle Shoals to produce electricity independently of and not required for government use for the sole purpose of proprietary or commercial sale to the public, at wholesale or retail, for non-governmental uses, is beyond the power of Congress to authorize.

(6) Assuming, without deciding, that the steam-electric plant and hydro-electric generators installed at Muscle Shoals were lawfully constructed for national defense and that by reason of the termination, suspension or obsolescence of the original use there is not sufficient governmental use to absorb currently their entire capacity, Congress cannot lawfully authorize the Tennessee Valley Authority to operate such parts of the plant as are no longer required for governmental use or as are not currently required for governmental use for the sole purpose of generating electricity admittedly not required for governmental use in order to market this electricity for profit, either by sale at the dam or in support of a commercial utility system proposed to be established and operated by Tennessee Valley Authority.

(7) The production of electricity for the sole purpose of filling long time contracts or commitments entered into by Tennessee Valley Authority for the supply of the public with electricity, at wholesale or retail, under the circumstances shown on this record, is not production for a lawful governmental use.

(8) There may be surplus emplacements and surplus

capacity in hydro-generators installed at Wilson Dam, that is, emplacements or capacities not presently required for the production of electricity for governmental use. This circumstance does not authorize the Congress to authorize the use by the United States or any agency thereof of those emplacements or the hydro-generators not required for governmental use in the commercial operation of the units in the production and sale of electricity to the public.

(9) There are decisive distinctions between (a) the sale or conservation (for future use) by the government of government property lawfully acquired but no longer required or not presently required for government use and (b) the utilization by the government itself of such property for the conduct of an ordinary commercial business on or by means of the property. The same or like distinctions exist as to power plants, emplacements and hydro-generators lawfully constructed by the government for a governmental use and no longer required or not presently required for governmental use. As to such units Congress may authorize the sale, or such custodianship of the units as may reasonably relate to their reservation or conservation for governmental use, but this principle does not authorize Congress to create and authorize TVA or any wholly owned agency of the United States to use the property for commercial and proprietary production of electricity for sale to the public for non-governmental use.

(10) There are distinctions in law under the evidence in this record between

(a) the leasing of power emplacements lawfully established in navigation or national defense dams, awaiting their related need for governmental use;

(b) the lawful installation of turbo-generators in such dams or the lawful construction of steam-electric plants related to government use and the leasing of such emplacement and generators or plants

(c) the installation of the hydro-electric units and the commercial operation of the plant by the government itself in generating electricity for sale at the generating plant to fill commercial contracts or utility service assumed by the government;

(d) the commercial business of generating electricity and its commercial transmission and distribution in service utility in type.

The function intended by TVA under the evidence in relation to service, utility in type, in the area ceded by the contract of January 4, 1934, transcends the function of conservation or disposition of government property, involves continuing service and commercial functions by the government to fill contracts not governmental in origin or character.

(11) Except when the Tennessee Valley Authority operates the electric plants and properties subjected to its care by the Tennessee Valley Authority Act (assuming its validity), substantially in excess of requirements and marginal reserves for governmental use, there is not a sufficient amount of electricity to set up a commercial electricity program such as proposed by TVA. To the extent that Tennessee Valley Authority intentionally commits itself to sell in the market and thereupon produces electricity to fill the commitment, in known excess of any requirement and reasonable margin for governmental use, it can not properly be said that Tennessee Valley Authority is disposing of a surplus unavoidably or reason-

ably produced in supplying a current government requirement.

(12) Congress cannot by substantially overestimating or overproviding the electricity required for a lawful governmental use lawfully capitalize the error to the extent of authorizing the Tennessee Valley Authority or other agency of the United States to employ the excess capacity as a means for establishing and operating the equivalent of a public service utility network in the Tennessee Valley under the circumstances shown by this record.

(13) Congress can not authorize the construction of a plant for national defense and thereupon, when the war is over or in anticipation of another war, utilize the plant for ordinary commercial operation by the United States in the production of commodities for proprietary sale for profit in competition with citizens of the State. That principle covers the utilization by Tennessee Valley Authority of so-called surplus capacity at Muscle Sheals in the business of operating an electric system in the area.

(14) The Court can not conclude that Tennessee Valley Authority is disposing of a bona fide surplus of electricity actually existing and unavoidably created in the light of the fact that Tennessee Valley Authority is proceeding with construction which will enormously, progressively and indefinitely add to such surplus, both new and old units being interconnected into a common pool in support of long term commercial commitments and public service operations by TVA.

(15) Congress can not, in lieu of taxation, authorize Tennessee Valley Authority to enter into the commercial

power business for the purpose of reimbursing the government for the cost of improvements to navigation, where such commercial business has, as proposed by Tennessee Valley Authority on this record, no relation to any lawful governmental function.

(16) Congress has no lawful power to authorize the Tennessee Valley Authority to subject the United States or any agency of the United States to an actionable obligation to perform a proprietary service for the public generally in North Alabama either by conducting utility operations in the area or to the extent of a commitment for the production of electricity for sale at wholesale or retail where such function, as upon this record, has no relation to any governmental purpose. This conclusion applies to the objectives sought to be accomplished by Tennessee Valley Authority in part by means of the contract of January 4th, 1934. Any such authority from Congress would be illegal because without foundation under the Constitution, and it is unnecessary to determine whether such action would be at the same time affirmatively violative of the Tenth Amendment, void as an infraction of sovereignty or as constituting a delegation and impairment of the legislative discretion of Congress, or invalid by reason of other objectives of Tennessee Valley Authority shown by the record or by reason of electricity policies set out in the Tennessee Valley Authority Act.

(17) The plan and program of the Tennessee Valley Authority, in furtherance and execution of which the Tennessee Valley Authority entered into the contract of January 4th, 1934, is a plan and program for the operation by Tennessee Valley Authority of a system for the generation, transmission and distribution of electricity. Its proposed

functions are utility in type. Under its contracts with the various municipalities to be served the service is to endure for at least twenty years, and involves a service which by reasonable implication is permanent in its nature. This purpose, based on the intentional generation of electricity by Tennessee Valley Authority in excess of intended governmental use, and being necessarily withdrawn from that use by its commitment to the utility program, would constitute illegal proprietary operations, and would be and is illegal, whether conducted as a utility or by direct sale by Tennessee Valley Authority either at wholesale or retail and at the dam or after transmission.

(18) The contract of January 4th, 1934, expressly provided for the transfer of all or substantially all of the lines and properties of the Alabama Power Company for the service of the ceded area, included transmission lines, rural distribution systems and certain urban distribution systems, and contemplated the eventual transfer of fourteen urban distribution systems. This contract, expressly contemplating service of the ceded area by the Tennessee Valley Authority with electricity to be generated or purchased by the Tennessee Valley Authority for that purpose, was in furtherance of illegal proprietary operations by the Tennessee Valley Authority in violation of the Federal Constitution and void. The contract was accordingly ultra vires and void as to the Alabama Power Company.

(19) Performance of the contract of January 4th, 1934, would involve substantial loss and injury to the Alabama Power Company, including, inter alia, the loss or abandonment of franchises, licenses, going business and service area supporting its general system and power facilities and

unless resisted would tend to invite a progressive encroachment on its service area by the Tennessee Valley Authority.

(20) For the management and the Board of Directors to yield to the proposal and program of the Tennessee Valley Authority and to execute and go forward with the contract for the transfer of properties in proximate furtherance of its illegal proprietary operations, unnecessarily (because of its illegality) and to the injury of the Alabama Power Company, constituted a breach of duty on part of the Board of Directors and management of the corporation.

(21) It is not necessary to the foregoing conclusion that the directors or that the Commonwealth & Southern Corporation, its dominant stockholder, should be shown to have acted fraudulently or in bad faith or from evil motives, or that the contract should have been exacted by the Tennessee Valley Authority under circumstances constituting administrative oppression or malevolence (**American Bank and Trust Co. vs. Federal Reserve Bank**, 256 U. S. 350). The breach of duty to the injury of the corporation in not resisting and the action of the management in going forward with an arrangement in furtherance of an illegal objective by the Tennessee Valley Authority, and therefore ultra vires, is remediable at suit of the plaintiffs although the directors and Commonwealth & Southern may have considered it more desirable to yield to the Tennessee Valley Authority program than to resist and incur the risk and consequences of resistance inherent or threatened.

(22) In this situation the plaintiffs as holders of preferred stock of the Alabama Power Company, on behalf of themselves and other preferred stockholders, had the right to demand that the Alabama Power Company refrain from

performance of the contract of January 4th, 1934, and take such action as might be necessary to protect the corporation in the premises. The stockholders made due demand, and upon refusal of the management and the Board of Directors to take action, they became vested with the right to maintain this suit for relief.

(23) The conclusion of the Court is that plaintiffs are entitled to maintain this suit within the principles laid down in

Dodge v. Woolsey, 18 How. (59 U. S.) 331
Chicago v. Mills, 204 U. S. 321
D. & H. Co. v. Albany etc. Co., 213 U. S. 435
Ex Parte Young, 209 U. S. 123
Greenwood v. Un. Fr. R. Co., 15 Otto (105 U. S.) 13
Smyth v. Ames, 169 U. S. 466
Pollock v. Farmers Loan & Tr., 157 U. S. 420 (158 U. S. 601)
Cotting v. Goddard, 183 U. S. 79
Smith v. Kansas City etc. Co., 255 U. S. 180
Brushaber v. U. P. R. Co., 240 U. S. 1

(24) The proof sustains the right of the plaintiffs to have the contract of January 4th, 1934, annulled in its entirety as to Alabama Power Company and for such additional relief as may be necessary or appropriate to give effect to the annulment of the contract and to protect the corporation from the consequences threatened by the contract itself, viz., the loss of business, franchises and service area to the Tennessee Valley Authority in pressing its illegal proprietary operations in the ceded area directly and through the defendant municipalities or other privies.

(25) The municipal defendants hold or propose to enter into 20 year contracts with the Tennessee Valley Authority

for the supply of electricity to said municipalities as soon as they shall obtain municipal distribution systems. The City of Athens already has its system. Such contracts, existing and proposed, give or tend directly to give effect to the aforesaid illegal plan and program of the Tennessee Valley Authority and are and will be in furtherance thereof. In the same category are or will be loans or grants of public funds made or to be made by the Tennessee Valley Authority, the Federal Emergency Administration of Public Works, or other federal agency to said municipalities in cooperation with TVA and with a view to their becoming a market for TVA's commercial power business. Said agreements, existing or proposed, between the said municipalities and the Tennessee Valley Authority will directly and necessarily involve competition with and displacement of the Alabama Power Company from the area served by the facilities and properties required to be transferred or expressly contemplated to be transferred out of the Alabama Power Company by the contract of January 4, 1934, hereby annulled. All such agreements constituting a means of and in furtherance of said illegal operation and all extensions of its lines, system and service by TVA to give effect to its proposed illegal operations in competition with and to the injury of the Alabama Power Company in the area of service of the facilities required or contemplated to be subjected to TVA service by TVA, at wholesale or retail, should accordingly be restrained.

(26) The Electric Home and Farm Authority, Inc., is a proprietary agency of or for the TVA in the promotion of the sale and in the financing of the sale of electric appliances in furtherance of the TVA power policy and program herein defined. The contract between the Alabama Power Company and Electric Home and Farm Authority, Inc.,

dated May 21, 1934, was entered into pursuant to a covenant required of the Alabama Power Company by Section 19 of the agreement of January 4, 1934. The plan, program and objective of said Electric Home and Farm Authority was and is illegal as an agency of and in furtherance of the TVA program and for the further reason that there appears to be no valid authority in or pursuant to any Act of the Congress of the United States for the creation or functioning of said EHFA or its appropriation or use of the funds of the United States. Said agreement is therefore deemed to be proximately related to the contract of January 4, 1934, and also being intrinsically illegal, should be annulled.

(27) This Court has, in the view taken of the relief to which plaintiffs are entitled, given no consideration to the request or prayer of plaintiffs for a declaratory judgment or to any phase or matter of relief not reflected in the final decree herein and in these conclusions of law and is without prejudice to such further independent or supplemental relief as may hereafter be sought by plaintiffs or by the Alabama Power Company in its own right.

This April 11th, 1935.

W. I. Grubb,
U. S. District Judge.

Filed in Office,
April 11th, 1935.
W. S. Lovell, Clerk.

To:

Messrs. Cabaniss and Johnston
Solicitors of Record for the Plaintiffs

Please take notice that the following motion, together with the attached findings of fact and conclusions of law will be presented to the Honorable William I. Grubb, Judge of the United States District Court at his chambers in Birmingham at 10:00 AM, Saturday, March 9, 1935.

(Signed) James Lawrence Fly
Solicitor for the Defendants

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al
Plaintiffs,
v.
Tennessee Valley Authority et al
Defendants.
} In Equity No. 355

MOTION FOR FINDINGS OF FACT AND CONCLUSIONS OF LAW

Now come Tennessee Valley Authority, Electric Home and Farm Authority, Inc., Arthur E. Morgan, Harcourt A. Morgan, and David E. Lilienthal, defendants in the above styled cause by their solicitors and present to the Court for adoption the following findings of fact and conclusions of law, and respectfully move the Court separately as to each finding of fact and conclusion of law that each of them be adopted by the Court as its findings of fact and conclusions of law pursuant to Equity Rule No. 70½.

(Signed) James Lawrence Fly
Solicitor for Defendants

I hereby certify that a copy of the foregoing motion has been served upon Messrs. Cabaniss and Johnston, Solicitors of Record for the plaintiffs.

(Signed) William C. Fitts, Jr.
Solicitor for Defendants

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al
Plaintiffs,
v.
Tennessee Valley Authority, et al
Defendants.
} In Equity No. 355

FINDINGS OF FACT AND CONCLUSIONS OF LAW MADE

Pursuant to Equity Rule 70½

A final decree having been rendered in this cause on March 2, 1935, this Court now makes findings of fact and conclusions of law respectively, pursuant to Equity Rule 70½, as follows:

FINDINGS OF FACT

I. Historical Background on the Problem of Navigation on the Tennessee River

1. The problem of improving navigation upon the Tennessee River has been considered by Congress almost continuously since 1824. (Neely R. 502) (D. Ex. 9)

2. In 1836 the State of Alabama, with the aid of a grant of public lands from the Federal Government, built the

first Muscle Shoals canal, which was intended to relieve the most serious navigation problem on the Tennessee River, that created by Muscle Shoals rapids. The canal consisted of 16 locks, 32 feet wide and 120 feet long, with a five foot lift. It was never a success and fell into disuse. (Neely R. 503) (Barker R. 538-540).

3. In 1871 the canal was rebuilt by the Federal Government with 11 locks, at a cost of approximately $3,200,000. It was opened to traffic in 1890, but was not a success because the shallow water at each end prevented navigation except during periods of high water. (Neely R. 503; Barker R. 541).

4. From 1852 to 1918 Congress authorized and made appropriations for seventeen surveys and projects covering all portions of the river, and during the same period ten such projects were authorized upon the tributaries at a total expenditure of $25,297,468.03. (Barker R. 538 et post).

5. In 1918 Congress authorized the construction of Wilson Dam, which provided a nine foot slack water development over the Muscle Shoals rapids and flooded out the existing canal. A high dam of this type was the only feasible means of eliminating this most serious obstruction to navigation. (Barker R. 539 to 541).

6. In order to obtain a nine foot channel for the distance of 16 miles afforded by the Wilson Dam pool, it would have been necessary either to build six low dams in a series of steps, or to construct a canal along one of the banks and place a series of locks in the canal. The construction of the series of low dams, the widening of the existing canal, and putting in larger locks would not have been feasible or practicable. (Barker R. 539 to 541, 548).

7. Pursuant to the Congressional authorization, a comprehensive survey of the Tennessee River and its tributaries, with respect to navigation, flood control, and power development, was undertaken by the War Department Corps of Engineers and completed on March 24, 1930. This report is contained in House Document No. 328 of the 71st Congress, Second Session.

8. The recommendations contained in House Document No. 328 were adopted by Congress in the Rivers and Harbors Act of 1930. (Randolph R. 436; Barker R. 555, 559, 560).

II. Existing Conditions on the Tennessee River With Respect to Navigation

1. In its present condition, the Tennessee River is not satisfactory for navigation, for the following reasons:

(a) The flow of water in the river is subject to great variations. In the summer months, the stream flow runs as low as about eight to ten thousand second feet at Florence, and approximately two thousand second feet at Knoxville. In the winter months at Florence, it generally runs between one hundred thousand and two hundred thousand and reaches a maximum of four hundred thousand second feet, and at Knoxville it has been as great as one hundred and ninety-five thousand second feet. (Barker R. 534).

(b) There are numerous natural obstructions in the river, consisting principally of the shoals and bars. (Barker R. 533, 536).

(c) In certain portions of the river, there is an extremely steep slope and a resulting swift current. (Randolph R. 145, 207; Barker R. 533, 534).

(d) The minimum navigable depth in the different portions of the river varies from a minimum of one foot upwards. (Randolph R. 153; Barker R. 531, 545, 547).

2. Because of the numerous obstacles to navigation, the traffic on the Tennessee River at the present time is much less than could be expected with a satisfactory waterway. Any improvement in the navigation facilities upon the river will increase the extent and value of such traffic. (Barker R. 598).

(a) During the past 45 years, at least, there has been considerable traffic upon the Tennessee River, increasing from one-half million tons in 1891 to a maximum of over two million in 1930. (Barker R. 549).

(b) Because of the various impediments to navigation, this traffic has nearly all been in short stretches of the river. Through traffic on a commercial scale is not feasible at the present time. (Barker R. 550, 551).

(c) There is at the present time a large amount of potential through traffic which could be economically carried by water if the Tennessee River were satisfactorily improved. (Barker R. 550, 598).

3. A nine foot minimum channel in the Tennessee River will permit continuous navigation up and down the Tenessee River through the Ohio and Mississippi Rivers without change in type of vessel, transhipment, or method of loading. (Barker R. 553; Randolph R. 148).

4. The only feasible method of obtaining an adequate navigation channel over the entire length of the Tennessee River is by means of a canalized development; that is, by a system of dams. This result cannot be obtained by open channel improvements. (Randolph R. 145, 207).

5. It is possible to obtain a nine foot minimum channel throughout the entire length of the Tennessee River from Knoxville to the mouth by means of a series of 32 low-lift dams, in addition to the dams already in the river. (Edgerton R. 940; Barker R. 554; Randolph R. 154).

6. The high dams of the type of those being constructed by the Tennessee Valley Authority in the main stream, as shown by the evidence, will also afford a channel of nine foot minimum depth and will furnish a type of navigation superior to that which would be provided by the alternative low dams. (Barker R. 557, 560, 565; Pillsbury R. 669, 674, 677, 687; cf. Randolph R. 161). (Randolph R.)

(a) A series of high dams will save a total of at least nine hours and twenty minutes in lockage time alone on a trip from Paducah to Knoxville. The average lockage time on a low dam is 26 minutes and on a high dam 36 minutes. (Barker R. 557, 565; Pillsbury R. 670; Randolph R. 210; cf. R. 151; Morgan (D) R. 107).

(b) The high dams will result in an anual saving of over one million dollars in operation and maintenance charges. (Barker R. 557, 565, 615; Pillsbury R. 670; cf. R. 678; Randolph R. 209).

(c) Slack water from high dams will extend up the tributaries for considerable distances, thus improving navigation on the tributaries and reducing the cost of future improvements. (Barker R. 557, 565, 568; Pillsbury R. 671; Randolph R. 221; Morgan (D) R. 114).

(d) The more stable pool levels furnished by the high dams will reduce the first cost and annual operating charges of terminal developments by eliminating the great fluctuation always experienced in low dam pools,

and the navigation and terminal difficulties attending moderate floods will be completely removed. (Barker R. 558, 565, 570; Pillsbury R. 671; Randolph R. 221).

(e) The greater width and depth of the high dam pools will permit greater speed with less power and fuel consumption, and will mean additional saving in time. In the wide pools a large fleet of barges of the type in common use can follow a direct course and the manipulation of large tows is greatly facilitated. (Barker R. 558, 565, 566, 570; Pillsbury R. 670, 671; cf. Randolph R. 159; Morgan (d) R. 114).

(f) The high velocities which impede upstream traffic about 30% of the time in the low dam plan will exist less than 3% of the time with a high dam improvement. (Barker R. 558, 565, 570; Pillsbury R. 671; Randolph R. 208).

(g) The silt accumulations which normally occur in the upper end of each pool will be much less in the high dam plan, due to the lesser number of pools. This will result in an annual saving in dredging costs. (Barker R. 558, 565, 567; Pillsbury R. 670; cf. Randolph R. 205; Morgan (d) R. 107).

(h) The high dams give additional depth over practically the entire length of the pools, which is very useful for navigation. (Barker R. 556).

(i) With a series of low dams, large tows must be broken more often, resulting in loss of time and additional expense. (Randolph R. 209).

(j) The interference with navigation from the possible misuse of dams in the head waters is less with a series of high dams than with a series of low dams. (Edgerton R. 917).

(k) The low dams in the Ohio River have been replaced by high dams because not satisfactory. (Pillsbury R. 675).

(l) The dams on the Monongehela River are fixed dams of the same general type as the high dams being constructed on the Tennessee, but their height was limited because of the immense cost of flowage rights in the densely populated area bordering on the river. (Pillsbury R. 674).

(m) The United States Army Engineers have found the high dam more feasible for navigation purposes and have found the chief limiting factor in determining the height to construct the dams is the cost of flowage rights.

(n) The higher the dam, the greater the advantages for navigation purposes. (Pillsbury R. 674, 675).

7. A series of high dams will result in the best possible type of navigation on the Tennessee River. (Barker R. 582).

8. The Tennessee Valley Authority is conducting investigations to determine the feasibility of the construction of each of the seven high dams suggested in House Document No. 328. (Barker R. 1001, 1002; Woodward R. 795).

III. **The Completion and Operation of Norris Dam Will Materially Improve Navigation on the Tennessee River and Certain Tributaries.** (Bowman R. 944; Morgan (D) 126).

1. The minimum navigable depth will be increased by releases from Norris as follows:

(a) From Chattanooga to the mouth of the Clinch River

from one foot to 2.7 feet. (Barker R. 585; Bowman R. 946).

(b) From Widows Bar to Guntersville, three feet to 4.8 feet. (Barker R. 585; Bowman R. 946).

(c) From Pickwick Landing to Paducah from 4.5 feet to six feet. (Bowman R. 947; Barker R. 585).

2. The increase in minimum depth resulting from releases from Norris will be of substantial benefit to commerce already using the Tennessee River, because: (Barker R. 585; cf. Randolph 212, 213, 170)

(a) The increased depth above Chattanooga will give a channel of approximately the minimum depth that now exists between the head of Wilson Dam pool and Widows Bar, for the securing and maintenance of which the corps of engineers had gone to considerable trouble and expense (Barker R. 588, 589).

(b) The increase in the minimum depth between Pickwick Landing and the mouth by providing a minimum channel of at least six feet in depth will give a better channel than a six foot project on the Missouri River from Kansas City to the mouth, in securing which Congress has expended in the neighborhood of $70,000,000. (Barker R. 588).

3. Norris Dam will be useful as a link in any ultimate plan for the improvement of the Clinch-Powell River system, giving the minimum navigable depth of six feet from the dam site 38 miles up the Powell River and 55 miles up the Clinch River. (Barker R. 587, 590; cf. 637; cf. Randolph 172, 176, 216, 217, 1866).

4. Before the passage of the Tennessee Valley Authority Act, the United States Army Engineers had begun the

formulation of plans for the construction of a dam known as Cove Creek Dam, at the site where Norris Dam is now being constructed. (Barker R. 583, 632).

5. So far as navigation facilities are concerned, Norris Dam is being constructed by the Tennessee Valley Authority in substantial conformity with the plan and design of the United States Army Engineers. (Barker R. 583, 585, 632; cf. Randolph 176).

6. The plans of the United States Army Engineers for Cove Creek Dam made no provision for a barge lift. (Woodward R. 784; Defense D. Ex. 20; (Letter from General Pillsbury)). (Pillsbury R. 668).

7. The installation of a barge lift at the present time is not warranted by the existing traffic on the Clinch River, in its present condition. (Barker R. 592; D. Ex. 20, Letter from General Pillsbury). (Pillsbury, R. 668).

IV. **The Completion of Wheeler Dam Will Materially Improve Navigation on the Tennessee River and Certain Tributaries.**

1. The construction of a dam or series of dams at the site where Wheeler Dam is now being constructed has been considered by the United States Army Engineers and by Congress, in connection with the elimination of obstructions to navigation in that section of the river, since 1914. (Barker R. 574).

2. At the time the Tennessee Valley Authority was created, the United States Army Engineers had commenced the construction of a lock and had completed plans for a dam at this site. (Barker R. 574, 620, 633; Pillsbury R. 669).

3. The only substantial difference between the design of Wheeler Dam as it is being constructed by the Tennessee Valley Authority and the design originally planned by the United States Army Engineers, is that the present design calls for an additional height of 11 feet. (Barker R. 575, 620) (Pillsbury R. 668).

4. The additional 11 feet of height will materially aid navigation, because:

(a) This additional height extends the nine foot slack water pool all the way back to Guntersville, Alabama, an important terminal point, whereas the design of the United States Army Engineers would necessitate the construction of an additional low-lift dam, in order to accomplish that result. (Barker R. 576, 562).

(b) This additional height extends the nine foot slack water navigation up the Elk River, which is a potentially important artery of commerce, for a distance of approximately 28 miles, and eliminates one low-lift dam that would have been necessary to accomplish the same result under the design of the United States Army Engineers. (Barker R. 577, 568).

5. All of the navigation features of the Tennessee Valley Authority plans for the construction of Wheeler Dam have been approved by the United States Army Engineers. (Pillsbury R. 666, 682).

6. In any plan for the improvement of navigation on the Tennessee River, the site at which Wheeler Dam is being constructed is the most logical place at which to begin the carrying out of the program. (Pillsbury R. 667; Barker R. 572; Bowman R. 985).

7. The construction of four low-lift locks and dams on

the Tennessee River would have been necessary to extend a nine foot channel from Wheeler Dam to Guntersville and the construction of three low-lift locks and dams would have been necessary to extend a nine foot channel for the distance of 28 miles up the Elk River. (Barker R. 564, 568).

8. The completion of Wheeler Dam will increase the minimum depth of the river below the site of Pickwick Dam three-tenths of a foot. (Bowman R. 951; Barker R. 577).

V. The Construction of Pickwick Dam Will Materially Improve Navigation on the Tennessee River and Certain Tributaries.

1. In the improvement of navigation on the Tennessee River, the site at which Pickwick Landing Dam is being constructed is the next most logical one after the completion of Wheeler Dam. (Barker R. 572).

2. The most necessary and desirable improvement in navigation upon the Tennessee River at the present time is that which will result from the completion of Wheeler and Pickwick dams, since they together will render navigable that section of the river between Pickwick Landing and Guntersville. (Barker R. 572; Pillsbury R. 667).

3. In selecting the exact location for Pickwick Dam, the Tennessee Valley Authority selected the site that was most advantageous to navigation, rather than the most economical power site. A site twelve or fifteen miles upstream at Parkers Landing, which was considered, would have been more economical for the production of power, but would have been inferior from a navigation standpoint. (Barker R. 581; Bowman R. 983-987, 1003, 1012).

4. The lock at Pickwick Dam has been designed by the United States Army Engineers, and the dam has been so designed as to place the lock upon that side of the river which is most convenient for navigation purposes; whereas, for the purposes of power generation, it would have been advisable to place the lock upon the opposite side of the river. (Barker R. 581). (Bowman 1059-60).

5. All of the navigation features of the design for Pickwick Dam, as it is being constructed by the Tennessee Valley Authority, have been approved by the United States Army Engineers. (Barker R. 552; Pillsbury R. 666, 682). (Bowman R. 1059-60).

6. The construction of Pickwick Dam will extend slack water back to Wilson Dam, will overcome the very serious rapids and bars in that section at Buck Island and Tuscumbia Bar, and will flood out the existing Riverton Lock and Colbert Shoals Canal which are impediments to large-scale navigation because of the small size of their facilities. (Barker R. 562, 580).

7. In order to obtain similar results from the alternative low dams, the construction of three low-lift locks and dams on the main stream would be necessary. (Barker R. 563, 568).

8. The completion of Pickwick Dam will extend slack water navigation of a minimum depth of nine feet for a distance of approximately 18 miles up Bear Creek, which may become an important link in the proposed Tombigbee Canal new being surveyed under direction of Congress. The construction of three low-lift locks and dams would be necessary to accomplish the same result. (Barker R. 568).

9. The construction of Pickwick Dam will increase the minimum depth of the river below the site of Pickwick Dam two tenths of a foot. (Bowman R. 951; Barker R. 580).

VI. **The Three Dams That Are Now Being Constructed by the Tennessee Valley Authority Considered Together Will Materially Improve Commercial Navigation Upon the Tennessee River and Certain Tributaries.** (Randolph R. 214; Barker R. 587, 633).

1. Specifically the three dams will increase the minimum channel depth from the mouth of the Tennessee River to Pickwick Landing a distance of two hundred seven miles from 4.5 feet to 6.5 feet.

2. The three dams will increase the minimum channel depth from Pickwick Landing to Guntersville to nine feet, which together with Wheeler Dam and Lock No. 1 will give a minimum navigable depth of nine feet from Pickwick Landing to Guntersville.

3. The three dams will increase the minimum navigable depth from Guntersville to Chattanooga from three feet to four and one-half feet.

4. The three dams will give a minimum navigable depth of six feet from the Norris Dam site thirty-eight miles up the Powell River and fifty-five miles up the Clinch River.

5. The three dams will give a minimum navigable depth of nine feet for varying distances up certain of the tributaries of the Tennessee, including Bear Creek and Elk River.

6. The three dams will add 16,500 cubic feet per second

to the Ohio and Mississippi Rivers during low flow periods, thereby aiding navigation on the Ohio and Mississippi rivers.

VII. The Flood Problem on the Tennessee River.

1. The average annual flood damage in the Tennessee Valley for the past fifty years has been estimated by the United States Army Engineers in House Document No. 328 at $1,000,000. (Kimball R. 811).

2. This estimate is conservative and does not include many intangible elements of damage, such as depreciation in property values, interruption to business and commerce, and epidemics resulting from unsanitary conditions. (Kimball R. 812).

3. The average annual flood damage at Chattanooga for the past fifty years has been estimated by the United States Army Engineers in House Document No. 328 at $680,000. This estimate is conservative and does not include many intangible elements of damage. (Kimball R. 813).

4. Any flood on the Tennessee River of similar height to that of 1927 has the effect of interfering with and interrupting commerce and trade, not only on the river itself, but at various points along the river, especially at Chattanooga. This includes interruption of interstate commerce along the highways and interference with terminals for interstate railroad transportation located at the City of Chattanooga. (Kimball R. 822-823).

5. The area of the City of Chattanooga within the zone of flood hazard contains property values estimated at $47,176,975.00, exclusive of all public service corporation

property and all non-taxable property. With those values included, there is at least $75,000,000 worth of property within the flood zone (Kimball R. 814).

6. All previous attempts to obtain protection by means of local works at Chattanooga alone have failed. (Kimball R. 823).

7. It is not feasible or practical to construct local protection works at Chattanooga of sufficient magnitude to alleviate the flood menace. (Kimball R. 824-825).

8. The supplementing of local protection work at Chattanooga by upstream, headwater storage, is a practical, feasible, and necessary method of alleviating the flood menace. (Kimball R. 825).

9. There is now, and was at the time of the passage of the Tennessee Valley Authority Act a serious flood menace in the Tennessee Valley. (Kimball R. 811-812).

VIII. **The Construction and Operation of Norris Dam Will Substantially Reduce Destructive Flood Waters in the Tennessee Valley Generally and Particularly at Chattanooga.**

1. As being constructed, the Reservoir at Norris Dam will provide a total of 2,900,000 acre feet of storage. (Kimball R. 828; Bowman R. 941).

2. 1,400,000 acre feet of storage is specially allocated in the design of the dam for flood storage, which amount will always be available for that purpose. (Kimball R. 828; Bowman R. 949).

3. In addition to the 1,400,000 acre feet specially allocated, a considerable portion of the remaining storage

will generally be available for flood control purposes. (Kimball R. 828; Bowman R. 949-951; Sargent R. 878).

4. It has been estimated by the United States Army Engineers in House Document No. 328, based upon their plan for Cove Creek Dam, which called for considerably less flood storage than the present plan for Norris, that the normal operation of the dam would have decreased the flood crest at Chattanooga in the flood of 1926 by 5.7 feet. (Kimball R. 829).

5. The normal operation of Norris Dam, under its present design, using only the 1,400,000 acre feet specially allocated for flood storage, would have decreased the flood crest at Chattanooga in the flood of 1886 by 11½ feet and would have decreased the flood crest at Chattanooga in 1917 by 6.7 feet. (Kimball R. 830-831).

6. The reduction at Chattanooga could have been materially increased by using additional storage by operation of a draw-down. (Kimball R. 831).

IX. Both Wheeler and Pickwick Dams Are Valuable for Flood Control Purposes in the Tennessee Valley.

1. The operation of Norris Dam, using only the 1,400,000 acre feet specially allocated for flood control, in conjunction with high dams in the main river with the ten-foot surcharge storage would have reduced the flood crest at all points along the Tennessee River in the flood of 1926 much more than would the operation of Norris Dam alone. (Kimball R. 840).

2. Each of the dams that is now under construction by the Tennessee Valley Authority is essential to adequate flood protection in the Tennessee Valley. (Kimball R. 840).

3. Each of the dams that is now under construction by the Tennessee Valley Authority substantially contributes to adequate flood protection in the Tennessee Valley. (Kimball R. 840).

4. A system of thirty-two low dams in the main river would be of no value for the control of floods in the Tennessee Valley. (Kimball R. 837; Bowman R. 944).

5. The building and operation of any high dams in the Tennessee River of the type of Wheeler and Pickwick dams will provide protection to all points below the dams that is not afforded in the present situation where the flow of waters is uncontrolled. (Kimball R. 836-838). (Randolph R. 1879-1885).

X. The Construction of Norris Dam and High Dams in the Main River, Such as Pickwick and Wheeler, Will Serve to Decrease Flood Crests in the Lower Mississippi River.

1. The most serious flood problem upon the Mississippi River is between Cairo at the Junction of the Ohio and Mississippi Rivers and the Gulf, or what is generally known as the lower Mississippi River. (Clemens R. 696).

2. Following the flood of 1927, which was the most destructive of record, a comprehensive study was made of the entire problem by the United States Army Engineers. (Clemens R. 697).

3. A certain degree of flood protection upon the Mississippi River may be obtained either by a system of levees supplemented by floodways, or by a system of tributary reservoirs, but neither system alone affords adequate protection. (Woodward R. 774-775).

4. The levee system was adopted by the United States Army Engineers following their study of the problem. (Clemens R. 698).

5. In order to obtain adequate protection, the levee system should be supplemented by a system of tributary reservoirs. (Woodward R. 775).

6. The flood-ways provided for in the adopted plan have not yet been completed, and their ultimate completion is in doubt. (Clemens R. 707; Woodward R. 771-772).

7. If the present plan for flood-ways is carried out, about one-third of the alluvial valley of the lower Mississippi is to be confined permanently to flooding; about one-third of the valley will be completely protected, and the remaining one-third will be subject to frequent intermittent flooding. (Woodward R. 772-773).

8. The adopted plan provides levees of such a height that the top of the levee will be one foot above the high water mark of the greatest flood that is to be reasonably expected. (Woodward R. 774).

9. There is a difference of opinion among those who have studied the subject as to whether this one foot is a sufficient margin of safety in case of an unusually severe flood. (Woodward R. 774).

10. Any additional margin of safety would materially reduce the existing danger of a breaking of the levees and would eliminate the element of uncertainty and fear in the minds of inhabitants of the flood zone. (Woodward R. 775).

11. There are two possible ways of obtaining the addi-

tional margin between the top of the levees and the crest of the flood. This can be accomplished either by raising the height of the levees or by reducing the flood crest by means of tributary reservoirs. (Clemens R. 701, 705). (Woodward R. 775).

12. It is not feasible to add any additional height to the existing levee system. (Randolph R. 1859-1860).

13. It is possible to materially reduce the use of the floodways and the flooding of backwater areas by reducing the flood crest in the lower Mississippi by means of tributary reservoirs. (Woodward R. 775).

14. In recent years, a comprehensive study has been conducted by the Mississippi River Commission in accordance with Congressional direction in order to determine the advisability of supplementing the adopted plan for flood control on the lower Mississippi by means of reservoirs upon the main tributaries of the Mississippi, including the Tennessee. (Clemens R. 705).

15. In case of the greatest flood reasonably to be expected, the flood crest in the lower Mississippi could be reduced by a comprehensive system of reservoirs upon the tributaries by about seven or eight feet. (Clemens R. 701).

16. While the development of a reservoir system upon any one of the main tributaries will not by itself solve the flood problem on the lower Mississippi, such development upon the Tennessee alone will substantially aid by supplementing the protection afforded by the levee system. (Clemens R. 703).

17. At a time when flood stages exist upon one or more of the other tributaries of the Mississippi, and there is

no flood upon the Tennessee, a system of reservoirs upon the latter river would be of substantial assistance in reducing the flood crest upon the lower Mississippi. (Clemens R. 705, 713-714).

18. In the comprehensive system of tributary reservoirs studied by the Mississippi River Commission, there is included a system of reservoirs on the Tennessee River and its tributaries, including Norris Dam, Wheeler Dam, Pickwick Dam, and others, which system upon the Tennessee and its tributaries would afford a total of about ten and one-half million acre feet of storage. (Clemens R. 708).

19. Norris, Wheeler, and Pickwick dams are among the most efficient for flood control on the Lower Mississippi of any possible dams that can be constructed upon the Tennessee River and its tributaries. (Clemens R. 708).

20. A series of low dams upon the Tennessee River would have no effect whatever in reducing the flood crests on the lower Mississippi River. (Clemens R. 714).

21. A combination of storage dams upon the tributaries of the Tennessee River operating in conjunction with high dams upon the main stream, would be of more benefit for flood control upon the lower Mississippi than a series of storage dams upon the tributaries of the Tennessee River without any high dams in the main stream. (Clemens 714-715).

22. It is possible to predict flood crests above fifty-two feet at Cairo from five to seven days in advance. (Clemens R. 714; cf. Randolph R. 100, 201).

23. There is a material difference in the benefits to be derived in the reduction of flood crests on the lower Mis-

sissippi between reservoirs upon the tributaries of the Mississippi that are within a seven-day prediction distance of Cairo and those beyond that distance. Those within the prediction distance can be operated on prediction of flood stages at Cairo while those beyond can be only partly operated upon such predictions. (Clemens R. 714-716; Woodward R. 766-767).

24. Wheeler and Pickwick Landing Dams are within the prediction distance of Cairo. (Clemens R. 716).

25. Norris Dam is not strictly within the prediction limit, but is on the edge. (Clemens R. 716).

26. With a system of high dams in the main stream of the Tennessee River operating in conjunction with Norris, when a critical stage is predicted at Cairo, Norris Dam can be placed in operation immediately while the storage space in the main stream dams can be held in reserve. At the critical time, the main stream storage would then be available to take up the waters which were not stored at Norris and to take off the flood flow at exactly the right time. The main stream dams are close enough to the lower Mississippi so that the effect of the waters stored or released upon the flood crest at Cairo can be predicted in advance with considerable accuracy. (Clemens R. 717).

27. Norris Dam will be of material assistance in reducing flood crests in the lower Mississippi. (Clemens R. 718-719).

28. The high dams upon the main stream of the Tennessee and storage dams upon the tributaries of the Tennessee can be effectively operated to reduce flood crests on the lower Mississippi when there is no flood in the Tennessee River itself, but when the flood stage upon the lower Mississippi has resulted from the floods from one or more of

the other tributaries. With approximately ten and one-half million acre feet of storage available upon the Tennessee and its tributaries, with such space distributed between main river dams and tributary storage dams, it would have been possible to hold out sufficient water on the Tennessee River and its tributaries to have reduced the Mississippi flood crest in 1927 at Cairo by about 1.6 feet. (Clemens R. 725).

29. If high dams upon the main stream of the Tennessee, and storage dams upon the tributaries of the Tennessee, were operated solely with the view of affording protection from floods in the Tennessee Valley, such operation would be sixty per cent as effective, so far as the lower Mississippi is concerned, as if the reservoirs were operated strictly for the purpose of lowering the crest at Cairo. (Clemens R. 721).

30. In order to afford any measure of protection against floods in the lower Mississippi by means of dams upon the Tennessee or its tributaries, it is necessary to take advantage of the natural storage in the Tennessee Valley by controlling the flow of the waters in the Tennessee River by means of high dams in the main stream. (Clemens R. 722).

31. The reduction of flood crests by means of controlling the flow into the lower Mississippi from the Tennessee and its tributaries would reduce the area submerged by floods in backwater sections would reduce the costs of maintenance of the levees and would reduce the use of floodways. (Woodward R. 776).

XII. **Each Dam Now Being Constructed by the Tennessee Valley Authority, When Completed, Will Result in a Substantial Improvement in the Navigable Channel of the Tennessee River and Its Tributaries.**

XIII. **Each Dam Now Under Construction by the Tennessee Valley Authority Will, When Completed, Substantially Assist in the Control of Floods in the Tennessee Valley.**

XIV. **Each Dam Now Under Construction by the Tennessee Valley Authority Will, When Completed, Materially Assist in the Reduction of Destructive Flood Waters Upon the Lower Mississippi.**

XV. **In Order to Improve Navigation Upon the Tennesseee River, Reduce Destructive Flood Waters in the Tennessee Valley, and Reduce Destructive Flood Waters in the Mississippi Valley by Means of Engineering Works Upon the Tennessee River and Its Tributaries, It Is Necessary to Construct High Dams Such as Wheeler and Pickwick Landing Dams as Now Being Constructed by the Tennessee Valley Authority in the Main Stream of the Tennessee River and Storage Dams Such as Norris Dam as Now Being Constructed Upon the Tributaries of the Tennessee River as Shown by the Evidence.** (Barker R. 601; Clemens R. 732; Woodward R. 783; Edgerton R. 921; Bowman R. 992; Kimball R. 840).

XVI. The Effect of the Dams Under Construction by the Tennessee Valley Authority Upon the Value and Usefulness of the Existing Government Properties at Muscle Shoals.

1. Eight generators with a combined capacity of 184,000 KW were installed at Wilson Dam by the War Department upon its completion in 1926. (Bowman R. 955).

2. The extreme variation in stream flow at Wilson Dam results in a great variation in the amount of firm power available there. (Bowman R. 955).

3. This variation in the amount of firm power results in the lack of a dependable supply of continuous available power and greatly limits the value and impairs the usefulness in war or in peace of the existing government properties at Muscle Shoals. (Bowman R. 955).

4. The amount of power available at Wilson Dam varies from a minimum of continuous power of 50,000 KW to a maximum of the installed capacity of 184,000 KW. (Bowman R. 955).

5. The value and efficiency of the existing government properties at Muscle Shoals will be enhanced by means of the increase in the amount of firm power available at Wilson Dam from 50,000 KW to 90,000 KW, which will result from the operation of the Norris reservoir for stream flow regulation. (Bowman R. 957-958).

6. Wheeler Dam will increase the amount of firm power available at Wilson Dam from 90,000 KW to 97,000 KW, and will thus increase the value and efficiency of existing government properties at Muscle Shoals. (Bowman R. 960).

7. The completion of Pickwick Dam by extending slack

water navigation to the Wilson pool will make possible the operation of the facilities at Wilson Dam at a greater peak load. (Bowman R. 960).

8. The reservoir at Norris Dam will be operated entirely for storage purposes during seven months of the year, and water for low flow regulation in the river below will be released only during five months of the year. (Almon R. 1602).

9. The completion of Norris Dam and the installation of generators will create no firm power at that dam because the generators there can be operated only during four or five months each year. (Almon R. 1602).

10. If after the completion of Norris Dam and the installation of the generators a proper inter-connection is made between Norris Dam and Wilson Dam, the effect of the operation of the two generators at Norris will be to supplement the effect of the stream flow regulation by further increasing the firm power available at Wilson Dam. (Almon R. 1603).

XVII. **The Hydro Electric Features of the Dams.**

1. It is the plan of Tennessee Valley Authority to install only two 50,000 KW generating units at Norris Dam when completed, and only one 32,000 KW generating unit at Wheeler Dam. The plans of the United States Army Engineers for the construction of Cove Creek Dam included the installation of three generators. (Woodward R. 785; Bowman R. 963).

2. There are no plans for the installation of any generating units at Pickwick Dam. (Bowman R. 964).

3. As a result of the completion of the present plans for

construction and installation, the total amount of firm continuous power available at all of the dams, including the eight generators installed at Wilson Dam by the War Department, will be 202,000 KW. (Bowman R. 958).

4. The storing of water in a reservoir storage dam of the type of Norris Dam in flood seasons and the subsequent release of such waters for the purpose of the improvement of navigation in the river below in low flow seasons necessarily makes available during a certain period of the year a large amount of water power. (Bowman R. 987-988).

5. The construction of high dams of the type of Wheeler and Pickwick in the main stream of the Tennessee River for the improvement of navigation and the control of floods in the Tennessee Valley, and the release through such dams of the ordinary river flow in all seasons of the year necessarily makes available great amounts of water power. (Bowman R. 987-988).

6. It is not practicable to construct either storage dams upon the tributaries or high dams in the main stream without providing any emplacements or intakes and then, after construction, make provision in such dams for emplacements and intakes. (Bowman R. 987-988).

7. The cost of Wheeler Dam as shown by the evidence as it is being constructed by the Tennessee Valley Authority with power house, eight emplacements for generators and one generating unit installed, is $29,548,000. The approximate cost of a dam of the same height which would have the same value for navigation and flood control, without any facilities provided for the subsequent generation of power, is $24,654,000. (Bowman R. 990, 991).

8. The cost of Pickwick Dam as shown by the evidence

as it is being constructed by the Tennessee Valley Authority with power house and six emplacements for generators, is $22,000,000. The approximate cost of a dam of the same height which would have the same value for navigation and flood control, without any facilities provided for the subsequent generation of power, is $19,000,000. (Bowman R. 991).

9. The Tennessee Valley Authority now has available at Wilson Dam and from time to time will have available from Norris and Wheeler Dams certain amounts of electric power in excess of that presently needed for the operation of government properties. (Almon R. 1578).

10. The proceeds from the sale of electric power will liquidate a part or all of the cost of the construction of the dams. (Morgan Deposition).

11. The construction and operation of the Wilson Dam necessarily produces surplus water power which can be used to generate electricity. (Morgan Deposition).

12. Unless the water power at Wilson Dam over and above that amount which is required for the operation of governmental equipment, such as the nitrate plants, lighting the villages and the operation of the locks, is converted into electricity, it will be wasted. (Morgan Deposition).

13. Unless the water power available at Norris and Wheeler Dams over and above the amount which is required for the operation of governmental properties is converted into electricity, it will be wasted. (Morgan Deposition).

14. The construction of high dams in the main stream of the Tennessee River, such as Wheeler and Pickwick Dams, and the construction of storage dams on the tribu-

taries of the Tennessee, such as Norris Dam, makes possible the reduction of destructive flood waters in the Tennesse and Mississippi River Valleys, that would not be possible with low navigation dams and also makes possible the creation of more advantageous conditions for navigation than would be provided by low dams in the Tennessee River. (Morgan Deposition).

15. The construction of high dams such as Wheeler, Pickwick and Norris, which are necessary in order to carry out the purposes of the Tennessee Valley Authority Act, can be more economical by generating and selling the electric power made available by such high dams. (Morgan Deposition).

(a) It is the policy and practice of the Federal Government to charge no tolls upon any of the inland waterways of the United States. (R. 1068).

(b) A substantial part of the cost of flood control projects cannot be recovered by the Federal Government by charges or assessments, since benefits are so difficult of measurement that it is impossible to assess charges. (Kimball R. 812, 1068).

(c) The revenue from the sale of water power is the only source from which the Federal Government may reasonably expect to recover any part of the expense involved in providing navigation and flood control on the Tennessee and Mississippi Rivers. (Morgan Deposition).

(d) The sale of electric power generated from surplus water available at the navigation and flood control dams, and the use of the revenues from such sales to amortize the cost of the dams or to build other navigation and flood control structures, will be of aid to the Federal Government in the completion and continuance of the improve-

ment of navigation and the reduction of destructive flood waters on the Tennessee River and its tributaries. (Morgan Deposition).

XVIII. **The Problem of Unified Development and Control of Dams and Reservoirs for Navigation and Flood Control.**

1. In order to obtain the maximum benefits for navigation and the control of flood waters in the Tennessee Valley, it is essential that the construction of dams upon the Tennessee River and its tributaries should proceed in such a manner that those dams that are most necessary should be constructed first and at the most advantageous sites. (Edgerton R. 914; Bowman R. 985).

2. It is not practicable to obtain such a development of the Tennessee River and its tributaries for navigation and flood control purposes by means of dams constructed by private interests, or by cooperation between the United States and private interests. (Edgerton R. 918).

3. It is not practicable to obtain adequate improvement on the Tennessee River and its tributaries to the extent necessary for adequate navigation facilities and flood protection by means of dams constructed by private interests alone, or by cooperation between United States and private interest. (Edgerton R. 918; Bowman R. 984-986).

4. It is not practicable to obtain the cooperation of private interests under the plan authorized by the Rivers and Harbors Act of 1930 in the construction of a series of combined navigation, flood control and power dams, upon the Tennessee River and its tributaries, or in the construction of any one of the dams that are necessary for navigation and flood control purposes. (Bowman R. 977).

5. The only practicable way in which a complete orderly development of the Tennessee River and its tributaries for the combined purposes of navigation and flood control, can be obtained is by the construction of dams by the United States Government. (Bowman R. 977).

6. In order to obtain the maximum benefit to navigation upon the Tennessee River and the maximum reduction of destructive flood waters in the Tennessee and Mississippi River Valleys by the construction of dams and the operation of reservoirs upon the Tennessee and its tributaries, close coordination in the operation of all the various reservoirs is essential. (Clemens R. 732; Bowman R. 975; Sargent R. 871).

XIX. **The Use of the Water in the Reservoirs Upon the Tennessee River and Its Tributaries for the Generation of Power Frequently Conflicts with the Use of the Same Water for Navigation and Flood Control Purposes.** (Bowman R. 974; Sargent R. 871).

XX. **The Actual and Potential Uses of Power for the Operation of Government Properties.**

1. At the present time, power generated by the Tennessee Valley Authority at Wilson Dam is being used in these operations:

(a) Operation of the locks,

(b) Operations at the Wilson Dam and power house,

(c) Service to village at Wilson Dam and Muscle Shoals,

(d) Construction work and service to the construction camp at Wheeler Dam.

(e) Construction work and service to the Town of Norris at Norris Dam.

(f) Lighting the office building at Chattanooga, Tennessee.

(g) The manufacture of fertilizer at Nitrate Plant No. 2. (Almon R. 1577).

2. At the present time 68% of the power generated by the Tennessee Valley Authority in its operations is being used for the operation of government properties. (Almon R. 1578).

3. Power generated by the Tennessee Valley Authority is to be used in the manufacture of fertilizer at Nitrate Plant No. 2, which fertilizer is to be used on agricultural lands in a program of watershed protection as a supplement to reforestation measures, to prevent soil erosion in the Tennessee Valley. (McAmis R. 1252-1255).

(a) Erosion of the soil causes silting of the channels of navigable streams and of reservoirs, and increased severity of floods, which results in impediments to navigation. (D. Exhibit No. 38).

(b) Either forests or vegetative crop cover upon lands in a watershed tend to reduce the severity of flood waters. (Sherman R. 1080).

(c) Either forests or vegetative cover upon lands located in a watershed are useful in preventing the erosion of the soil and the subsequent silting of the navigable channels of streams and of reservoirs. (Sherman R. 1080).

(d) The problem of soil erosion is a serious national problem on 1,135,000,000 acres of land in the United States. (Sherman R. 1115).

(e) The problem of soil erosion is a serious one, in both nature and extent, in the Tennessee Valley. (Sherman R. 1115).

(f) The most serious erosion problem exists upon

agricultural land as distinguished from forest land. (Sherman R. 1118).

(g) The only method of obtaining protective cover upon agricultural lands as distinguished from forest lands is by the growth of thick growing farm vegetation. (Sherman R. 1124).

(h) The cultivation of the necessary cover crops upon agricultural lands is possible only through the agency of a proper cropping system, involving the growth of crops in rotation or in combinations so as to increase the proportion of soil improving and soil protecting crops and at the same time to decrease the proportion of tilled crops and bare land. (Pieters R. 1137).

(i) The proper cropping systems for these purposes cannot be adapted to the Tennessee Valley area without the addition of large amounts of phosphorus plant food to the soil, there being a deficiency of this plant food throughout the area. (Pieters R. 1149).

(j) During the past fifteen months the Tennessee Valley Authority has been engaged in the formulation and administration of a program for the control of erosion on agricultural lands located in the Tennessee Valley based upon the effective use of phosphorus plant food in cropping systems designed to make possible the cultivation of the necessary cover crops. (McAmis R. 1244).

(k) This program for the control of erosion on agricultural lands involves the discovery and manufacture of new forms of fertilizer and the distribution of such fertilizer to farmers in the valley conditioned upon its use in the growth of crops providing ample protection to the soil. (McAmis R. 1246).

(l) This program includes 7,000,000 acres of seriously eroding agricultural land in the Tennessee Valley. (McAmis R. 1254).

(m) It is estimated that the fertilization requirement is from 16 to 100 pounds of triple super-phosphate per acre. (McAmis R. 1254).

(n) The present program calls for the selection of 20 demonstration farms in each of the 100 counties in the valley, upon which the fertilizer will be applied in a demonstration program (McAmis R. 1250).

(o) It is the plan to extend this program over the entire area of the valley as rapidly as possible. (McAmis R. 1250).

(p) In the administration of this program, the facilities and personnel of the experiment stations and extension agencies of the agricultural colleges in each state in the Tennessee Valley will be used and this work will be coordinated with that now being conducted by the United States Department of Agriculture. Comprehensive contracts to this end have already been executed. (McAmis R. 1248).

(q) It is estimated that the initial total requirement of fertilizer for this program is 210,000 tons of triple super-phosphate per year. It is estimated that 10,000 KWH are required to produce one ton of phosphorus. It is therefore estimated that in meeting the requirements for fertilizer the power consumption at Nitrate Plant No. 2 will amount to 630,000,000 KWH per year. (Curtis R. 1279).

(r) At the present time, the Tennessee Valley Authority is operating two electric furnace units at Nitrate Plant No. 2 capable of producing 40,000 tons of triple super-phosphate per year, which would consume approximately 40,000,000 KWH in the operation. The present plans include the installation in the immediate future of two additional electric furnace units, which will double production and hence also double the present power requirements. (Curtis R. 1274).

(s) Experimental work is now being carried on in an attempt to eliminate the objectionable features of cyanamide as a fertilizer, which, if successful, will result in a great increase in the need for power at Nitrate Plant No. 2, since the cyanamide process is a heavy consumer of power. (Curtis R. 1280).

(t) The operation of Nitrate Plant No. 2 for the manufacture of fertilizer is the best practical method of maintaining that plant in a stand-by condition ready for use in case of war for the manufacture of munitions. (Curtis R. 1424).

XXI. Historical Background of the Muscle Shoals Properties.

1. The existing government properties at or in the vicinity of Muscle Shoals, Alabama, were constructed or acquired to promote the national defense. (Neely R. 502; Curtis R. 1412-1414).

2. Nitrate Plant No. 2 was constructed during the World War to provide a facility for the production of nitrogenous products necessary to the carrying on of war. (Neely R. 504; Curtis R. 1412-1415).

3. At the time of the construction of Nitrate Plant No. 2, it was intended for the production of nitrogenous war materials by the so-called nitrogen fixing process, which requires the use of a large amount of electric power in electric furnaces which were installed in Nitrate Plant No. 2 for that purpose. (Curtis R. 1412).

4. Wilson Dam was constructed after the war for the purpose of inter alia supplying the electric power necessary to the operation of Nitrate Plant No. 2 for the production of nitrogenous war materials. The eight generators at present installed at Wilson Dam were placed there by

the War Department after the war for the primary purpose of making available a supply of power for any subsequent operation of the nitrate plant. (Curtis R. 1415).

5. Since the completion of Wilson Dam in 1926, the Federal Government, through the War Department, has generated and sold to the Alabama Power Company substantial quantities of electric power. This company has been the only purchaser of power generated at Wilson Dam. (Almon R. 1571).

6. The Federal Government has received for the electric power thus generated and sold, a price commonly known as the "dump power price", which was far below the current comparable wholesale price. (Neely R. 505).

7. Between the time of its completion at a cost of approximately $58,855,000, and the passage of the Tennessee Valley Authority Act, Nitrate Plant No. 2 has not been used except for an occasional trial operation. (Neely R. 505).

8. Between the time of its completion in 1926 at a cost of approximately $46,950,000 and the passage of the Tennessee Valley Authority Act, the total gross revenue from Wilson Dam has been approximately $6,064,000. (Neely R. 500-501).

9. Since the completion of Wilson Dam and up until the passage of the Tennessee Valley Authority Act substantial quantities of potential electric power available at Wilson Dam have been wasted. In every year since 1926, but one, the amounts of potential electric power so wasted have been far in excess of that sold or used. (Almon R. 1570).

10. The Sheffield Steam Plant was constructed during the World War at a cost of approximately $12,326,000 for

the purpose of operating Nitrate Plant No. 2. (Neely R. 500).

11. The Sheffield Steam Plant between the time of its construction and the passage of the Tennessee Valley Authority Act has been very little used. (Neely R. 500).

12. The difference between the historical cost of the properties acquired or constructed by the United States at or in the vicinity of Muscle Shoals, Alabama, for the purpose of promoting the national defense, and the total revenue from the sale or use of such properties is approximately $121,312,000, which figure represents the total unabsorbed cost of these properties. (Neely R. 501).

XXII. **War Time Usefulness of Nitrate Plant No. 2 and Wilson Dam.**

1. Nitrate Plant No. 2, with the aid of electric power furnished by Wilson Dam and the Sheffield Steam Plant can be operated to produce annually 110,000 tons of ammonium nitrate by the nitrogen fixing process. Ammonium nitrate is the principal inorganic compound used in modern warfare as a propellant. (Crom R. 1316). (Page 27).

2. A certain portion of Nitrate Plant No. 2 can be used to produce 110,000 tons of ammonium nitrate or nitric acid by the oxidation of synthetic ammonia, produced elsewhere and shipped to Muscle Shoals. (Curtis R. 1419).

3. Power is so important as a national defense asset that the War Department has organized a separate power division, the function of which is to insure an adequate supply of power to facilities essential to war production. (Crom R. 1316, 1326).

4. The present plan of the Commodities Division of the

Planning Branch of the War Department relies on Nitrate Plant No. 2 to supply to the War Department, or its appointed agencies, 110,000 tons of ammonium nitrate annually in the event of a major war. (Crom R. 1316).

5. The existence of these facilities which make available large quantities of nitrogenous war materials by use of the nitrogen fixing process or the oxidation of synthetic ammonia is a valuable national defense asset. (Curtis R. 1419).

6. If the appointed authorities in time of war should determine that it would be more advisable to produce the necessary nitrogenous war materials at Nitrate Plant No. 2 by the oxidation of synthetic ammonia, the 12 electric furnaces and their attendant equipment, such as transformers, wiring, etc., at Nitrate Plant No. 2 would be available for other war uses. Without substantial alteration, they could be used in war time to produce substantial quantities of certain specific war materials of which there were shortages in the World War or which are listed by the Planning Branch of the War Department as "critical" or "strategic" war materials. (Curtis R. 1425; Moore R. 1396).

7. The Planning Branch of the War Department has compiled a list of materials denominated as "strategic materials" which are the war materials of which there would probably be a shortage if foreign supplies were cut off. This list includes nitrates and nitric acid. (Crom R. 1310).

8. The Planning Branch of the War Department has compiled a list of so-called "critical materials" which are important war materials in which shortage would probably develop in the event of a major war. A substantial

portion of this list of "critical materials" is made up of those electric-chemical products which are commonly produced by electrical furnaces or electrolytic cells. Included specifically in this list of "critical materials" are aluminum, magnesium, abrasives, phosphorus, refractories, and various ferro-alloys and steels. (Crom R. 1310).

9. Many of the materials listed by the War Department as "strategic" or "critical", as well as the raw materials out of which a number of ferro-alloys are produced by electro-thermal method, are present in the Tennessee Valley. (Eckel R. 1361; Minton R. 1354).

10. Two of the electric furnaces at Nitrate Plant No. 2 have been adapted to produce phosphoric acid for phosphatic fertilizer. The other ten furnaces could be easily adapted to such purpose. Within a short period of time concentrators could be attached which would allow the daily production in each of these furnaces of approximately 40 tons of white phosphorus which is a "critical" war material. (Moore R. 1396; Curtis R. 1491).

11. White phosphorus was commonly used in the World War as a smoke screen and wounding weapon. Its use increased rapidly from the time of its initial utilization in the World War until the extent of its use was limited only by its availability. (Fries R. 1482).

Present plans of the War Department call for the availability of a large supply of white phosphorus for war use. (Crom R. 1316).

12. The availability of a substantial quantity of white phosphorus by the use of the electric furnaces at Nitrate Plant No. 2 is of substantial value to national defense. (Fries R. 1484).

13. The availability of the electric furnaces at Nitrate Plant No. 2 for the production of various war materials in war time listed as either "critical" or "strategic", when shortages in any or all of those materials occur, is a valuable national defense asset. (Minton R. 1351).

14. Each of the twelve furnaces at Nitrate Plant No. 2 is rated as an 8,300 KVA furnace. (Moore R. 1396).

15. If Nitrate Plant No. 2 is used in war time to produce 110,000 tons of ammonium nitrate by the nitrogen fixing process, such use will require the annual consumption of approximately 800,000,000 KWH annually. (Curtis R. 1416).

16. Nitrate Plant No. 2 and Wilson Dam are useful and desirable for the promotion of the national defense.

17. The acts of the Tennessee Valley Authority in its use of Nitrate Plant No. 2 and the addition of certain equipment and of the rehabilitation of existing equipment, the retention and training of the personnel capable of operating the plant, contribute to a more effective war-time use, if such use becomes necessary. (Curtis R. 1424).

XXIII. **Potential Governmental Uses of Power Related to the National Defense.**

1. The conducting of experiments with natural resources such as manganese located in the Tennessee Valley to the end of furnishing fertilizer products for agricultural purposes will make available additional sources of these materials in war time. (Minton R. 1349).

2. The existence of ample reserves of electric power is an important national defense asset. (Minton R. 1351; Curtis R. 1425, 1456).

3. In the last World War the increased demand for certain war materials which required large amounts of electric power for their processing resulted in a deficiency in the supply of electric power in various sections of the country. There was a power shortage in the vicinity of Niagara Falls where the electro-chemical industry of the country was largely centered. (Curtis R. 1413; Crom R. 1325).

4. During the World War there was a power shortage in the Southern States in the area of the Tennessee Valley. (Harris R. 1518).

5. The Tennessee Valley is the only self-contained protected munitions center in the United States and there are present in the valley various minerals and natural resources which are the bases of many important electro chemical products, which are war materials. (Echol R. 1866).

5½. The Tennessee Valley has the following advantages from the standpoint of production of war materials: (1) invulnerability to attack; (2) adequate transportation facilities; (3) availability of great variety of mineral resources; (4) proximity to steel and industrial centers; (5) easy access to the coasts; (6) equable climate; (7) abundant supply of reliable labor.

6. In making provision for emplacements and intakes in the navigation and flood control dams such as Pickwick and Wheeler, the Tennessee Valley Authority is creating a potential power reserve which would be useful in time of war or emergency to meet possible power shortages in the Tennessee Valley or contiguous areas. (Harris R. 1518).

7. The increase of the amount of electric power avail-

able at Wilson Dam increases the value of the properties at Muscle Shoals for national defense. (Curtis R. 1456).

8. In time of war hydro-electric power is more valuable and useful than steam power since it does not require coal or the use of transportation facilities. (Curtis R. 1413).

9. The installation of generating facilities in existing dams or dams under construction in advance of war is desirable from the standpoint of the national defense. (Crom R. 1325).

XXIV. **The Sale of Power and the Acquisition of Transmission Lines.**

1. At the present time the Tennessee Valley Authority is generating at Wilson Dam power in excess of the amount required to serve its own properties and for the operation of the locks. (Almon R. 1578).

2. The Board of Directors of the Tennessee Valley Authority will continue to generate at Wilson Dam power in excess of the amount required to service its own properties and for the operation of the locks. (Morgan, Deposition).

3. The Tennessee Valley Authority will generate power at Wilson Dam in excess of the amount required to service its own properties and for the operation of the locks with the object of selling such excess power. (Morgan, Deposition).

4. The sale of such power will prevent the waste of such power that would otherwise occur, and will result in obtaining revenue from such sale which may be applied in liquidating a portion of the costs of the dams constructed and to be constructed in the Tennessee River and its tributaries. (Morgan, Deposition).

5. The Tennessee Valley Authority will, unless enjoined, use the transmission lines that are the subject of the contract of January 4, 1934, for the transmission of power generated at Wilson Dam for sale to municipalities and to rural communities. (Almon R. 1582).

6. The demand for power in the territory served by the transmission lines that are the subject of the contract of January 4, 1934, can be supplied by power generated at Wilson Dam. (Almon R. 1582).

7. The area involved in this suit will be served by means of these transmission lines with power generated at Wilson Dam. (Almon R. 1583).

8. The only transmission lines leading to and from Wilson Dam are owned and controlled by the Alabama Power Company and affiliated companies. (Almon R. 1580).

9. The area within a radius of 150 miles of Wilson Dam is served exclusively, with the exception of a few municipal generating plants, by the Commonwealth and Southern Company and its subsidiaries, and the Electric Bond and Share Company and its subsidiaries. (Almon R. 1592).

10. Under existing conditions the only possible purchasers of power generated at Wilson Dam at the dam are the subsidiaries of the Commonwealth and Southern Company. (Almon R. 1596).

11. Under existing conditions only the subsidiaries of the Commonwealth and Southern Company and the subsidiaries of the Electric Bond and Share Company are in a position to acquire a transmission line or lines to or from Wilson Dam. (Almon R. 1596, 1626).

12. Ninety-seven per cent of the rural residents in the Tennessee Valley are at the present time without electric service of any kind. (Kable R. 1790).

13. There are many rural communities within easy transmission distance of Wilson Dam that are now without electric service of any kind. (Kable R. 1792).

14. In order for the Tennessee Valley Authority to extend electrical service to rural communities and residents within transmission distance of Wilson Dam not now served, it is necessary that these transmission lines or duplicating ones be acquired or constructed. (Almon R. 1601; Kable R. 1794).

15. The Tennessee Valley Authority is now engaged in extending electric service to rural communities in close proximity to Wilson Dam not now served as quickly as possible. The transmission lines involved in this suit would be useful and valuable in rendering such service. (Kable R. 1792).

16. The servicing of the properties in suit will not impair the efficiency of the navigation, flood control and national defense activities of Tennessee Valley Authority. (Morgan, Deposition).

17. The rural distribution lines in suit are attached directly to the transmission lines, and service from such lines is an incident of the transmission function, rather than a part of the distribution function. (Falck R. 1702, 1701).

XXV. Relation of Transmission Lines to Interstate Commerce.

1. Two of the transmission lines in suit will carry power

from Wilson Dam across the state borders of Alabama into Mississippi and Tennessee. (Almon R. 1583).

2. A substantial amount of the power used in Mississippi, Alabama, Tennessee and Georgia is power that has been generated in some state other than the state where used. (Almon R. 1584).

3. Upon the completion of Norris Dam and the transmission line between Norris and Wilson Dam, during certain portions of the year the power sent over the transmission lines in suit would be power generated outside the State of Alabama. (Almon R. 1604).

4. The transmission lines in suit are interconnected with the transmission system of the Alabama Power Company which is an integral part of a network used in the interstate transmission of electricity and in operating under the terms of the contract of January 4, 1934 these lines would be used in interstate commerce. (Almon R. 1585).

XXVI. **Existing Practice of the Bureau of Reclamation With Reference to the Generation and Sale of Power.**

1. The Bureau of Reclamation of the Department of the Interior has for many years and is now engaged in the practice of selling power generated at dams constructed by the Bureau to corporations, municipalities, and individuals. (Exhibits R. 1562-1567).

2. In order to dispose of the power generated by it upon favorable terms the Bureau of Reclamation has constructed transmission lines from dams constructed by it. (Exhibits R. 1562-1567).

3. For the express purpose of earning revenue with which to liquidate a part of the cost of the dam struc-

tures, the Bureau of Reclamation has installed generating capacity at several of the dams constructed by it over and above the capacity necessary to generate a sufficient supply of power to meet the Bureau's own needs. The Bureau of Reclamation has also by sales to corporations, municipalities and individuals, disposed of power generated by it by means of equipment originally installed in the dams to serve the requirements of the Bureau in its own activities. (Exhibits R. 1562-1567).

XXVII. **The Tennessee Valley Authority Is Not Engaged in Generating Electric Power at Any Place Other Than Muscle Shoals.**

1. The small generating units in Mississippi purchased by the Tennessee Valley Authority under the terms of the contract of January 4, 1934 are not regularly operated by the Authority, are maintained for emergency stand-by service and are being withdrawn from service as rapidly as possible. (Almon R. 1590).

2. The Tennessee Valley Authority is not engaged in selling electric power generated by it at any place other than Muscle Shoals. (Almon R. 1590).

XXVIII. **The Tennessee Valley Authority Is Not and at the Time of the Filing of This Suit Was Not Purchasing Electric Power for Resale to Any Person, Firm or Corporation.** (Almon R. 1590).

XXIX. **The Board of Directors of the Tennessee Valley Authority Has Duly and Legally Adopted a Resolution Electing to Exercise the Option Conferred Upon the Authority by the Terms of the Contract of August 9, 1934 to Refuse to Proceed With the Execution of Said Contract of August 9, 1934 and Duly Notified the Alabama Power Company of Such Action.** (Neely R. 497, 498).

XXX. **Plaintiffs Are Minority Stockholders Owning 1,085 Shares of Preferred Stock Out of a Total of 367,207 Shares of Preferred Stock Outstanding, and a Total of 3,375,000 Shares of Common Stock Outstanding, the Latter Being Owned by the Commonwealth & Southern Corporation, Which Corporation Owns the Controlling Interest in the Alabama Power Company, Tennessee Electric Power Company, Georgia Power Company, South Carolina Power Company and Mississippi Power Company, Each of Which Subsidiary Companies Carries on an Extensive Public Utility Business in Its Respective State.**

OUTLINE OF CONCLUSIONS OF LAW

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Section 2. Constitutionality of TVA Act and Activities Under the "Delegation of Power" Provision, Under the "Due Process" Clause of Fifth Amendment and Under the Tenth Amendment

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Section 8. Effect of Motives, Policy, Plans, Purposes or Intentions of TVA or Its Directors Upon the Validity of the TVA Act and Activities

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Section 9. Legal Right of Plaintiffs to Complain of TVA Activities

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CONCLUSIONS OF LAW.

Pursuant to Equity Rule 70½, the Court makes the following conclusions of law:

A. The Tennessee Valley Authority is authorized by the Tennessee Valley Authority Act to purchase transmission lines.

B. Congress has the constitutional power to authorize the Tennessee Valley Authority to purchase transmission lines.

C. The contract of January 4, 1934, between the Tennessee Valley Authority and the Alabama Power Company, to the extent that it provides for the sale and purchase of transmission lines, is authorized by the Tennessee Valley Authority Act.

D. The Tennessee Valley Authority Act, in so authorizing the purchase of such transmission lines, and the contract of January, 4, 1934, in providing for such purchase of transmission lines by the Tennessee Valley Authority, are within the constitutional powers of Congress.

E. The Tennessee Valley Authority Act authorizes the Tennessee Valley Authority to sell surplus power.

F. The Tennessee Valley Authority Act, in so authorizing the sale of surplus power, is within the constitutional powers of Congress.

G. The possibility that the transmission lines, subject of the contract of January 4, 1934, may be used by the Tennessee Valley Authority to transmit power in excess of a legal surplus does not affect the validity of the contract.

H. The legality or illegality of the motives, intentions, plan, program or policy of the Tennessee Valley Authority, or the directors thereof, in the purchase of the transmission lines, subject of the contract of January 4, 1934, cannot affect the validity of said contract of purchase.

I. The transmission lines, subject of the contract of January 4, 1934, can be used by the Tennessee Valley Authority in a lawful manner.

J. All power that can be generated at Wilson Dam in excess of the amount presently used by the Tennessee

Valley Authority and the United States is surplus power within the meaning of the Tennessee Valley Authority Act.

K. Where Congress authorizes the construction of dams for navigation and flood control purposes, and water power is thereby necessarily created, the conversion of said water power into electric power is substantially related to the performance of the functions in aid of navigation and flood control and is within the constitutional powers of Congress.

L. The sale of such power is substantially related to said functions and is within the constitutional power of Congress.

M. The sale of such power in such a manner as will liquidate or aid in liquidating the investment for such functions is substantially related thereto, and is within the constitutional powers of Congress.

N. Congress has the constitutional power to authorize the generation and sale of electric power available from surplus water at any dam constructed by the United States or its agents for the purpose of the improvement of navigation.

I. This Court Was and Is Wholly Without Jurisdiction to Entertain This Suit or to Enter the Final Decree Herein.

1. As to the defendants, Tennessee Valley Authority and Electric Home and Farm Authority, Inc., this suit is in essence a suit against the United States of America, and to annul a contract by the terms of which property is to be conveyed to the United States of America, and/or its agents.

2. This Suit challenges the constitutional authority and power of the United States of America to carry on the operations and activities provided for in the Tennessee Valley Authority Act of 1933.

3. This suit in essence constitutes an attempt to prevent the United States of America from proceeding with the performance of the contracts described in the bill of complaint.

4. The United States of America has not consented to be sued in this suit, and has not been made a party thereto.

5. The United States is a necessary and indispensable party to a suit of this character.

6. This suit does not present a justiciable controversy between the parties hereto.

a-1. Plaintiffs have failed to establish that the Board of Directors or the majority stockholders of the Alabama Power Company in executing the contract of January 4, 1934, were guilty of fraud, collusion, unfair dealing, or gross negligence.

a-2. Plaintiffs have failed to establish that the Board of Directors or the majority stockholders of the Alabama Power Company in executing the contract of January 4, 1934, acted under such compulsion as amounts in law to duress.

a-3. Plaintiffs have failed to establish that the Board of Directors of the Alabama Power Company abused their discretion in executing the contract of January 4, 1934.

a-4. Plaintiffs have failed to establish that the contract of January 4, 1934, was beyond the charter powers of the Alabama Power Company.

a-5. The plaintiffs herein are without such legal interest to maintain the action.

b. In a derivative suit the rights of plaintiff stockholders are no greater than the rights of their corporation.

c. This Court holds as a matter of law that the Alabama Power Company, if it had brought this suit, would have no standing whatsoever in a court of equity, because it would have had a clear and adequate remedy at law by reason of the matters and things alleged in the bill of complaint and shown by the evidence.

d. This Court holds as a matter of law that even if the said contract was ultra vires the Tennessee Valley authority, the Alabama Power Company if sued on such contract, either at law or in equity, would have a valid defense to such action.

e. The Court holds as a matter of law that, even if it be assumed that the Tennessee Valley Authority has no legal power to enter into the contract of January 4, 1934, such lack of power would not entitle the Alabama Power Company to maintain a suit in equity to rescind said contract upon the ground of lack of mutuality.

f. The Court holds as a matter of law that, even if it be assumed that the Tennessee Valley Authority has no statutory power to enter into the contract of January 4, 1934, such lack of power would not entitle the Alabama Power Company to maintain a suit in equity to rescind said contract.

g. The plaintiffs have failed to show any injury or immediate threat of injury (irreparable or otherwise) by reason of the execution of the performance of said contracts either to themselves or to the Alabama Power Company.

h. The possibility that either the United States or the Tennessee Valley Authority will later seek restitution of any considerations paid under the agree-

ments would afford no ground of complaint to the Alabama Power Company, or its stockholders.

(1) The possibility that either the United States or the Tennessee Valley Authority will seek restitution of the considerations is too remote.

(2) Neither the United States nor the Tennessee Valley Authority would have any standing in a court of equity or law to seek restitution of the consideration to the injury of the Alabama Power Company, or its stockholders.

i. The Court holds as a matter of law that this suit is premature because it clearly appears from the record that the trustee under one of the indentures of mortgage, Chemical Bank and Trust Company, has refused to release the properties covered by the contract of January 4, 1934, and therefore, neither the Alabama Power Company nor the plaintiff stockholders are threatened with any immediate loss or damage.

j. The Court holds as a matter of law that the plaintiffs herein are not entitled to injunctive relief against the performance of the contract of May 21, 1934, between Electric Home & Farm Authority, Inc., and Alabama Power Company, as the performance of said contract could result in no possible injury or damage to these plaintiffs.

k. The Court holds as a matter of law that the plaintiffs have no standing as minority stockholders of the Alabama Power Company to question the validity of the contract of May 21, 1934, between Electric Home & Farm Authority, Inc., and Alabama Power Company.

l. The Court holds as a matter of law that plaintiffs have no sufficient standing in a court of equity to complain of competition or threatened competition by the Tennessee Valley Authority with the Alabama Power Company, whether or not the competition or

threatened competition is ultra vires Tennessee Valley Authority.

II. **The Plaintiffs Are Not Entitled to Relief in Equity for the Reasons Set Forth in Conclusions of Law I (6) (a) to (l) Inclusive.**

III. **Neither the Tennessee Valley Authority Act of 1933 Nor Any of the Provisions Thereof as Applied to the Facts of This Case Is Unconstitutional as Being Improper Delegation of Legislative Power.**

IV. **Neither Sections 4 (j), 5 (l), 10, 11 and 12 of the Tennessee Valley Authority Act, Nor Any of Them, (as Applied to the Facts of This Case) Are Unconstitutional as Being in Violation of the Due Process of Law Clause of the Fifth Amendment to the Constitution of the United States.**

V. **Sections 5 (l), 10, 11 and 12 of the Tennessee Valley Authority Act Authorize the Execution and Performance of the Contracts for Sale of Power Between the Tennessee Valley Authority and the Purchasers of Such Power, Including Certain Municipalities as Described in the Evidence and as So Construed, Said Sections Are Not Unconstitutional as Being in Violation of the Due Process of Law Clause of the Fifth Amendment to the Constitution of the United States.**

VI. **Neither Sections 4 (j), 5 (l), 10, 11 and 12 of the Tennessee Valley Authority Act, Nor Any of Them, as Applied to the Facts of This Case, Are Unconstitutional as Being in Violation of the Tenth Amendment to the Constitution of the United States.**

VII. Sections 5 (l), 10, 11 and 12 of the Tennessee Valley Authority Act Authorize the Execution and Performance of the Contracts for the Sale of Power as Described in the Evidence Between Tennessee Valley Authority and Its Purchasers and as so Construed Said Sections of the Act Are Not in Violation of the Tenth Amendment of the Constitution of the United States.

VIII. The Tennessee Valley Authority Act Has Not Been Administered by the Authority in a Manner in Violation of the Due Process Clause of the Constitution of the Fifth Amendment, or the Tenth Amendment.

IX. The Court Holds as a Matter of Law That the Execution and Performance of Such Contracts According to Their Terms as Revealed by the Evidence by the Contracting Municipalities Does Not Constitute an Unconstitutional Surrender of the Sovereign Police Powers of the States.

X. The Court Holds as a Matter of Law That Surplus Power as that Phrase Is Used in the Tennessee Valley Authority Act, Includes All Electric Power That Is or Can Be Produced at Any Dam or Plant Under the Control and Supervision of the Tennessee Valley Authority, Which Is in Excess of the Existing Needs of the Tennessee Valley Authority or the United States Government in the Operation of Government Properties as Described in the Evidence.

XI. The Court Holds as a Matter of Law That Sections 5 (l) and 10 of the Tennessee Valley Authority Act Authorize the Tennessee Valley Authority to Generate and Sell Any Surplus Power That Is Produced or Which Can Be Produced at Any Dam or Plant Under the Control or Supervision of the Tennessee Valley Authority.

XII. Sections 5 (l) and 10 of the Tennessee Valley Authority Act, as so Construed and as Applied to the Properties at Muscle Shoals, Are Within the Constitutional Power of the Congress Conferred Upon It, by:

1. The "National Defense" powers as set forth in subsections 1, 11, 12, 13, 14, 15 and 16 of section 8 of Article I of the Constitution, and the "Necessary and Proper" clause as set forth in subsection 18 of section 8 of Article I of the Constitution.

2. The power to dispose of and make all needful rules and regulations regarding government-owned property, as set forth in subsection 2, section 3 of Article IV of the Constitution, and the "Necessary and Proper" clause.

3. The power of Congress to improve navigation, conferred upon Congress by the commerce clause as set forth in subsection 3 of section 8 of Article I of the Constitution, and the "Necessary and Proper" clause.

4. The general welfare clause as set forth in subsection 1 of section 8 of Article I of the Constitution, and the "Necessary and Proper" clause.

XIII. Sections 5 (l) and 10 of the Tennessee Valley Authority Act, as so Construed and as Applied to Wilson Dam, Are Constitutional.

1. The construction of Wilson Dam was a valid measure for the improvement of navigation and within the power conferred upon the Congress by the commerce clause of the Constitution.

2. The power to authorize the disposition of the water power at Wilson Dam as an incident to the construction and maintenance of Wilson Dam for navigation purposes is within the constitutional powers of Congress, and particularly within the power to regulate commerce, the power to dispose of and make all needful rules and regulations respecting government property, and the "Necessary and Proper" clause of the Constitution.

3. The power to provide intakes and emplacements for subsequent installation of generating facilities at Wilson Dam is within the constitutional power of Congress and particularly within the power conferred by the commerce clause and the "Necessary and Proper" clause of the Constitution.

4. The power to install and lease generating facilities at Wilson Dam is conferred upon the Congress by the Constitution and particularly by the commerce clause, the power to dispose of and make all needful rules and regulations respecting government-owned property, and the "Necessary and Proper" clause of the Constitution.

5. The generation and sale of surplus power, as defined in Conclusions of Law X, produced at Wilson Dam is within the constitutional powers of Congress and particularly is a valid incident to the construction and mainte-

nance of Wilson Dam for navigation purposes and within the power conferred upon the Congress by the Constitution in the commerce clause and the "Necessary and Proper" clause.

6. The generation and sale of electric power at Wilson Dam is a lawful measure for liquidation of the costs of construction of the dam and is related to the improvement of navigation and a valid measure under the commerce and "Necessary and Proper" clauses of the Constitution.

7. The operation by the Federal Government of the generators at Wilson Dam is within the constitutional powers of Congress and particularly is a lawful means of avoiding possible conflicts in the operation of Wilson Dam for navigation purposes and the disposition of the water power for power purposes and is within the power conferred on Congress by the Constitution in the commerce clause and in the "Necessary and Proper" clause.

8. The generation of surplus power, as defined in Conclusions of Law X, produced at Wilson Dam is within the constitutional powers of Congress and particularly is a lawful means of making marketable the government-owned water power at Wilson Dam and is a lawful improvement of government-owned property within the power conferred upon the Congress by subsection 2, section 3 of Article IV of the Constitution.

9. The sale of such surplus power produced at Wilson Dam is within the constitutional powers of Congress and particularly is a lawful means of disposing of government-owned property, within the powers conferred upon the Congress by subsection 2, section 3 of Article IV of the Constitution, the commerce clause, the "Necessary and Proper" clause, and the general welfare clause.

Defendants' Rejected Conclusions of Law.

XIV. The Tennessee Valley Authority Is Empowered Under Sections 10, 11 and 12 of the Tennessee Valley Authority Act of 1933 to Sell Surplus Power, as Defined in Conclusions of Law X, to States, Counties, Municipalities, Corporations, Partnerships or Individuals.

XV. Sections 10, 11 and 12 of the Tennessee Valley Authority Act, as Applied to Wilson Dam, Constitute a Lawful Grant of Authority Under the Provisions of the Constitution Previously Referred to in Conclusions of Law XII and XIII, Insofar as They Empower the Authority to Sell Surplus Power to Such Purchasers.

XVI. Sections 10, 11 and 12 of the Tennessee Valley Authority Act Authorize the Tennessee Valley Authority to Acquire by Purchase Transmission Lines for the Purpose of Transmitting and Selling Surplus Power, as Defined in Conclusions of Law X, to States, Counties, Municipalities, Corporations, Partnerships or Individuals.

XVII. As so Construed and as Applied to Wilson Dam, Sections 10, 11 and 12 of the Tennessee Valley Authority Act Are Within the Constitutional Powers Conferred Upon Congress by the Provisions of the Constitution Referred to in Conclusions of Law XII and XIII.

XVIII. The Provisions of Sections 10, 11 and 12 of the Tennessee Valley Authority Act of 1933 Empower the Tennessee Valley Authority to Make, Execute and Perform the Contract of January 4, 1934, and the Amendatory and Supplemental Agreements Described in the Bill of Complaint.

XIX. The Transmission Lines Described in the Agreement of January 4, 1934, and Agreements Supplemental Thereto, Are Means or Instrumentalities of Interstate Commerce, and the Congress Has the Power to Authorize the Acquisition of Such Lines Under the Power Conferred Upon It by Subsection 3 of Section 8 of Article I of the Constitution, Relating to the Power of Congress to Regulate and Promote Interstate Commerce.

XX. The Court Holds as a Matter of Law That Even if a Substantial Quantity of the Power Generated at Wilson Dam Will Not Be Needed by the Tennessee Valley Authority in the Operation of the Navigation Locks, Nitrate Plants and Other Governmental Properties Described in the Evidence, and Even if This Fact Was Known at the Time Such Excess Power Was Generated, Those Facts Do Not Operate to Deprive the Tennessee Valley Authority of the Legal Right to Sell Such Excess Electric Power or to Acquire Transmission Lines Whereby Such Electric Power May Be Transmitted and Sold.

XXI. All the Electric Power Originally Made Available at Muscle Shoals for the Operation of Nitrate Plant No. 2 for War Time for War Purposes, Is Surplus Power in Peace Time Within the Meaning of the Term "Surplus Power" as Used in the Tennessee Valley Authority Act and May Be Generated, Transmitted and Sold Under the Terms of the Act, and the Act as so Construed Is Constitutional Under the Powers Conferred Upon the Congress by the Clauses of the Constitution Specified in Conclusions of Law XII and XIII.

XXII. The Tennessee Valley Authority Act Authorizes the Making, Execution and Performance of the Agreements of January 4, and Supplemental Agreements Thereto, for the Disposition of Surplus Power as Defined in Conclusion of Law X, and as so Construed, the Act Is Constitutional Under the Powers Conferred Upon the Congress by the Clauses Specified in Conclusion of Law XII.

XXIII. Section 17 of the Tennessee Valley Authority Act Authorizes the Construction of Norris Dam According to Present Design and Specifications and As So Construed is Constitutional:

1. The Congress has the power to authorize the construction of Norris Dam to control destructive floods under the commerce clause of the Constitution, and the "Necessary and Proper" clause.

2. The Congress has the power to authorize the construction of Norris Dam to control destructive floods under the General Welfare Clause of the Constitution, and the "Necessary and Proper" clause.

3. The Congress has the power to authorize the construction of Norris Dam for the improvement of navigation under the commerce clause of the Constitution, and the "Necessary and Proper" clause.

4. The Congress has the power to authorize the construction of Norris Dam in order to increase the amount of primary power available at Wilson Dam under the "National Defense Powers" as set forth in subsections 1, 11, 12, 13, 14, 15 and 16 of Section 8 of Article I of the Constitution, and the "Necessary and Proper" clause.

5. The Congress has the power to authorize the con-

struction of Norris Dam in order to increase the primary power at Wilson Dam under the power conferred upon it to dispose of and make all needful rules and regulations respecting government properties as set forth in subsection 2 of section 3 of Article IV of the Constitution, and "Necessary and Proper" clause.

XXIV. **Section 17 of the Tennessee Valley Authority Act Authorizes the Installation of Generators At Norris Dam in Order to Increase the Primary Power Available At Wilson Dam By Suitable Interconnection, and Section 17 As So Construed, is Constitutional:**

1. The Congress has the power to authorize the installation and operation of such generating facilities at Norris Dam under the power conferred by the "National Defense Powers" as set forth in subsections 1, 11, 12, 13, 14, 15 and 16 of section 8 of Article I of the Constitution, and "Necessary and Proper" clause.

2. The Congress has the power to authorize the installation and operation of such generating facilities under the power to dispose of and make all needful rules and regulations respecting government properties as set forth in subsection 2, section 3 of Article IV of the Constitution, and "Necessary and Proper" clause.

XXV. **Section 4 (j) of the Tennessee Valley Authority Act Empowers the Authority to Construct Wheeler and Pickwick Landing Dams As Now Being Constructed As Shown By the Evidence, On the Main Stream of the Tennessee River, and Section 4 (j) As So Construed is Constitutional Under:**

1. The power of Congress to improve navigation and control destructive floods conferred upon Congress by the

commerce clause as set forth in subsection 3 of section 8 of Article I of the Constitution.

2. Under the General Welfare Clause as set forth in subsection I of section 8 of Article I of the Constitution.

XXVI. **The Declared Purposes of the Tennessee Valley Authority Act of 1933 Being the Maintenance and Operation of the Property Now Owned By the United States in the Vicinity of Muscle Shoals, Alabama, in the Interest of National Defense and For Agricultural and Industrial Development, the Improvement of Navigation in the Tennessee River and the Control of Destructive Waters In the Tennessee River and Mississippi River Basins and the Provisions of the Act Being Substantially Related to the Accomplishment of the Declared Purposes, this Court Can Not Look Behind the Declared Purposes of the Act.**

XXVII. **Norris Dam, Wheeler Dam and Pickwick Landing Dam and Each of Them as the Evidence Discloses They Are Being Constructed, Are Substantially Related to the Improvement of Navigation and the Control of Destructive Flood Waters.**

XXVIII. **Norris Dam, Wheeler Dam and Pickwick Landing Dam, and Each of Them, as the Evidence Discloses They Are Being Constructed, Are Reasonable and Appropriate Means for Carrying Out the Improvement of Navigation and the Control of Destructive Flood Waters, Even Though They May Also Serve Other Purposes Which Would Not Alone Have Justified Their Construction in Such Manner.**

XXIX. The Court Holds as a Matter of Law That Norris, Wheeler and Pickwick Landing Dams and Each of Them as the Evidence Shows They Are Being Constructed Are Reasonable and Appropriate Means of the Improvement of Government-Owned Properties.

XXX. The Court Holds as a Matter of Law That If the Acts of the Tennessee Valley Authority Are Authorized by the Act and the Act as So Construed Is Within the Constitutional Powers of Congress, the Policy of Congress Is Not Subject to Review by This Court.

XXXI. The Court Holds as a Matter of Law That the Motives or Policy of the Authority or of the Board of Directors or Any of Its Authorized Agents Can Not Affect the Validity of the Acts of the Corporation, the Board or Other Authorized Agents, if Such Acts Are Authorized by the Tennessee Valley Authority Act of 1933.

XXXII. The Court Holds as a Matter of Law That Any Oral or Written Statements Made or Published in Any Form by the Tennessee Valley Authority or by Its Directors in Relation to Its Plans, Motives or Intentions Can Not Lawfully Add to or Subtract From the Powers Possessed by It Under the Tennessee Valley Authority Act. This Court Further Holds That Any Such Statements Whether Written or Oral Are Wholly Immaterial and Irrelevant to the Issue of the Validity of the Contract of January 4, 1934, and the Amendatory and Supplemental Contracts Described in the Bill of Complaint.

XXXIII. The Court Holds as a Matter of Law That the Intent, Motive or Purpose of the Tennessee Valley Authority in the Construction of Any of the Dams as Shown by the Evidence Is Wholly Immaterial and Irrelevant to the Issue of the Validity of the Contract of January 4, 1934 or the Amendatory and Supplemental Contracts Described in the Bill of Complaint.

XXXIV. The Court Holds as a Matter of Law That the Intent and Purpose of the Tennessee Valley Authority in the Construction of Any of the Dams as Shown by the Evidence Have No Legal Bearing or Effect Upon the Validity of the Contract of January 4, 1934, or the Amendatory and Supplemental Contracts Described in the Bill of Complaint.

XXXV. The Court Holds as a Matter of Law That the Plaintiffs Can Not Complain of the Construction of Any of the Dams as Shown by the Evidence.

XXXVI. The Court Holds as a Matter of Law That the Plaintiffs Can Not Complain of the Construction of Wheeler Dam or Pickwick Landing Dam as Shown by the Evidence.

XXXVII. The Court Holds as a Matter of Law That the Plaintiffs Can Not Complain of the Construction of Pickwick Landing Dam as Shown by the Evidence.

XXXVIII. The Court Holds as a Matter of Law That the Plaintiffs Can Not Complain of the Making, Execution or Performance of the Contracts for the Sale of Power Between the Tennessee Valley Authority and the Purchasers of Such Power as Described in the Evidence.

XXXIX. The Tennessee Valley Authority Act Empowers the Corporation to Install and Operate Two Generators at Norris Dam and One Generator at Wheeler Dam and to Sell Any Power so Generated and Not Used by It or by the United States for the Operation and Maintenance of Government Property as Described in the Evidence.

XL. As so Construed, the Act Is a Valid Exercise of the Constitutional Powers Conferred Upon the Congress by the Provisions of the Constitution Specified in Conclusions of Law XII and XIII.

XLI. The Tennessee Valley Authority Act Empowers the Tennessee Valley Authority to Transmit and Sell All Electric Power Generated at Any or All of the Dams Constructed by It When Such Power Is Not Needed in the Operations of the Navigation Locks, Nitrate Plants, and Other Governmental Properties Described in the Evidence.

XLII. As so Construed, the Act Is a Valid Exercise of the Powers Conferred Upon the Congress by the Provisions of the Constitution Specified in Conclusions of Law XII and XIII.

XLIII. The Court Holds as a Matter of Law That the Tennessee Valley Authority Act Authorizes the Generation of Electricity for the Production of Fertilizer for Use on Agricultural Lands to Protect the Watershed of the Tennessee River and Its Tributaries and the Act as so Construed Is Reasonably Related to the Improvement of Navigation and Within the Powers Conferred Upon the Congress by the Commerce Clause of the Constitution.

XLIV. If the Sale of the Surplus Water, or the Generation and the Sale of Electric Power From Such Surplus Water, Which Is, or Will Become, Available at Dams Constructed by the Tennessee Valley Authority and Related to the Improvement of Navigation Will Aid the Tennessee Valley Authority and/or the United States in Financing Such Improvements to Navigation, Then a Law Authorizing the Generation and Sale of Such Electricity Is a Constitutional Exercise of Congressional Power Within the Meaning of Subsections 18 and 3 of Section 8 of Article I of the Constitution.

XLV. Under Subsection 2, Section 3 of Article IV of the Constitution the Congress Has the Power to Dispose of and Make Use of Property Acquired by the United States in the Exercise of Its Granted Constitutional Powers so as to Secure Income and Revenue to Aid in Financing the Activities Authorized Under the Granted Powers of the Constitution.

XLVI. All Property Lawfully and Legally Acquired by the United States in an Exercise of Its Constitutional Powers May Be Used or Disposed of in Any Manner That the Congress May Decide to Be Consonant With a Promotion of the General Welfare.

XLVII. The Tennessee Valley Authority Act Authorizes the Acquisition of Transmission Lines to Dispose of Any Surplus Power Necessarily Generated in an Effort to Generate Only Such Power as May Be Needed in the Operation of Government Properties as Described in the Evidence and as so Construed the Act Is Constitutional Under the Powers Specified in Conclusions of Law XII and XIII.

Done at Birmingham this .....day of March, 1935.

.....

District Judge.

In the United States District Court for the Northeastern Division of the Northern District of Alabama.

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.

No. 355
In Equity.

Filed April 11, 1935.

NOTICE OF APPEAL

To City of Tuscumbia, City of Sheffield, City of Decatur, Alabama Power Company, Chemical Bank & Trust Company, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilienthal, Electric Home & Farm Authority, Inc., Defendants in the Above Styled Cause:

You and each of you are hereby notified that the defendant, City of Florence, Alabama, is about to appeal to the United States Circuit Court of Appeals for the Fifth Circuit at the City of New Orleans, State of Louisiana, from the final decree of the United States District Court, for the Northeastern Division of the Northern District of Alabama, made and entered in the above entitled cause on to-wit: the 4th day of March, A. D. 1935, and is about to apply to the said District Court of the United States for the Northeastern Division of the Northern District of Alabama for the allowance of such an appeal. It hereby notifies each of you to join in said appeal if you so desire.

W. H. Mitchell
Solicitor for Defendant,
City of Florence.

Service of the above notice is accepted this April 10th, 1935.

J. E. Deloney, Jr.
Solicitor for the defendant,
City of Tuscumbia.

Stockton Cooke
Solicitor for the defendant,
City of Sheffield.

W. H. Mitchell
Solicitor for the defendant,
City of Decatur.

Martin, Turner & McWhorter
Solicitors for the defendant,
Alabama Power Company.

Courtland Palmer
J. H. Stokely
Solicitors for the defendant,
Chemical Bank & Trust Company.

James Lawrence Fly
Solicitor for the Defendant,
Tennessee Valley Authority,
Arthur E. Morgan,
Harcourt A. Morgan,
David E. Lilienthal
Electric Home & Farm Authority, Inc.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.

No. 355
In Equity.

Filed April 11, 1935.

PETITION FOR APPEAL

Comes now defendant, City of Florence, by its solicitor of record, and enters its appeal from the final decree made in this cause on the 4th day of March, 1935, granting a permanent injunction in the above entitled cause, to the United States Circuit Court of Appeals for the Fifth Circuit for the reasons specified in the assignment of errors which is filed herewith, and prays that such appeal be allowed without bond, and that citation issue as provided by law, and that a transcript of the record, proceedings, papers and evidence, upon which said final decree was made, duly authenticated, be sent to the United States Circuit Court of Appeals for the Fifth Circuit, sitting at New Orleans, Louisiana, for the purpose of having reviewed the ruling and decision in said final decree contained, and the errors therein corrected and said final decree reversed according to law.

The defendant above named further prays that the Court in the order allowing the appeal will grant leave to this defendant to appeal and assign errors separately without joining any of the other defendants in said appeal or assignment of errors.

W. H. Mitchell
Solicitor for Defendant,
City of Florence.

In the United States District Court for the Northeastern Division of the Northern District of Alabama.

George Ashwander et al, Plaintiffs, vs. Tennessee Valley Authority et al, Defendants.	No. 355 In Equity

Filed April 11, 1935.

ORDER ALLOWING APPEAL.

Upon petition of defendant, City of Florence, it is hereby ordered as follows:

1. That an appeal without bond is hereby allowed in the above entitled cause to said defendant, City of Florence, to the United States Circuit Court of Appeals for the Fifth Circuit from the final decree heretofore entered in said cause on, to-wit: the 4th day of March, 1935,

2. It appearing to the Court that the final decree from which this appeal is prayed ran against all of the defendants, it is hereby ordered that the defendant, City of Florence, have leave to appeal and assign errors separately, without joining any of the other defendants in said appeal or assignment of errors.

3. That a citation be issued, directed to George Ashwander, Wm. M. Browder, A. C. Garber, Joseph R. Cook, Jr., Bessie M. Gray, C. H. Gray, Clifford L. Lamar, Mary P. London, F. W. Murray, Eugene C. Morgan, Joseph A. Norman, C. L. Torbert, R. H. Woodrow, Tutwiler Investment Company, a corporation, plaintiffs herein, to be and appear in said United States Circuit Court of Appeals for

the Fifth Circuit, sitting at New Orleans, Louisiana, within thirty days from the day of taking said appeal, as required by law.

4. That the Clerk of this Court transcribe, certify and transmit to said United States Circuit Court of Appeals for the Fifth Circuit a true and complete transcript of the record, exhibits, evidence and all other proceedings in this cause as required by law.

Done and ordered at Birmingham, Alabama, this 11th day of April A. D., 1935.

W. I. Grubb
Judge of United States District Court
in and for the Northeastern Division
of the Northern District of Alabama.

In the United States District Court for the Northeastern Division of the Northern District of Alabama.

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.

No. 355
In Equity

Filed April 11, 1935.

CITATION

United States of America

To George Ashwander, Wm. M. Browder, A. C. Carber, Joseph R. Cook, Jr., Bessie M. Gray, C. H. Gray, Clifford L. Lamar, Mary P. London, F. W. Murray, Eugene C. Morgan, Joseph A. Norman, C. L. Torbert, R. H. Woodrow, Tutwiler Investment Company, a corporation:

Greetings: You and each of you are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Fifth Circuit at the City of New Orleans, State of Louisiana, within thirty days from the 11th day of April, A. D. 1935, pursuant to an order allowing an appeal from the United States District Court for the Northeastern Division of the Northern District of Alabama, to the United States Circuit Court of Appeals for the Fifth Circuit from the final decree entered in the above-entitled cause on, to-wit: the 4th day of March, A. D., 1935, wherein the City of Florence is appellant and you are the appellees, to show cause, if any there be, why said final decree rendered against said appellant should not be re-

versed and corrected and why speedy justice should not be done to the parties in that behalf.

Witness the Honorable W. I. Grubb, Judge of the District Court of the United States for the Northeastern Division of the Northern District of Alabama, this 11th day of April A. D., 1935.

W. I. Grubb,
District Judge as Aforesaid.

We, the undersigned, as solicitors of record for plaintiffs in the above entitled cause, do hereby accept and admit service of the above and foregoing citation, this 11th day of April, 1935.

Cabaniss & Johnston,
Solicitors of Record for Plaintiffs.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.
No. 355
In Equity

Filed April 11, 1935.

ASSIGNMENT OF ERRORS OF DEFENDANT, CITY OF FLORENCE, ALABAMA.

Now comes City of Florence, Alabama, one of the defendants in the above styled cause, by its solicitor, and assigning errors separately files the following assignments of error upon which it will rely in the prosecution of the ap-

peal in this cause from the final decree heretofore entered, to-wit:

1. The District Court erred in entering the final decree herein.

2. The District Court erred in entering the final decree in this, to-wit; that said decree enjoins this defendant from concluding a loan and grant agreement with the Federal Emergency Administration of Public Works, such loan and grant to be used in purchasing or constructing a distribution system.

3. The District Court erred in overruling this defendant's motion to dismiss the original bill.

W. H. Mitchell,
Solicitor for Defendant,
City of Florence.

Presented April 11, 1935.
W. I. Grubb,
District Judge.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.
No. 355
In Equity.

Filed April 11, 1935.

PRAECIPE FOR TRANSCRIPT

To the Clerk of the United States District Court for the Northeastern Division of the Northern District of Alabama:

You will please prepare and certify a transcript of the record in the above-entitled cause, for use in the United States Circuit Court of Appeals for the Fifth Circuit, pursuant to an appeal in said cause taken and allowed the defendant, and in making up said transcript observe the following directions and include therein the following pleadings and proceedings, to-wit:

1. All those items covered in the praecipe filed in this case signed by James Lawrence Fly, as Solicitor for Defendants, Tennessee Valley Authority, et als.

2. Motion of Defendant, City of Florence, to dissolve the temporary restraining order of January 9, 1935.

3. The petition for this Defendant's appeal.

4. The order granting this appeal.

5. This Defendant's assignment of errors.

6. The citation and acceptance of service.

7. Notice of appeal to co-defendants and their acceptance of service.

8. A copy of this praecipe.

9. The certificate of the Clerk of this Court to the transcript.

You may omit all other papers and documents.

W. H. Mitchell
Solicitor for Defendant, City of Florence.

We hereby acknowledge service of a copy of this praecipe on this 11th day of April, 1935.

Cabaniss & Johnston,
Solicitors for Plaintiffs.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
v.
Tennessee Valley Authority, et al,
Defendants.
No. 355
In Equity

NOTICE OF APPEAL

To City of Florence, City of Tuscumbia, City of Sheffield, City of Decatur, Alabama Power Company and Chemical Bank & Trust Company, Defendants in the Above Styled Cause:

You and each of you are hereby notified that the defendants, Tennessee Valley Authority, Arthur E. Morgan, Har-

court A. Morgan, David E. Lilienthal and Electric Home & Farm Authority, Inc., are about to appeal to the United States Circuit Court of Appeals for the Fifth Circuit at the City of New Orleans, State of Louisiana, from the final decree of the United States District Court, for the Northeastern Division of the Northern District of Alabama, made and entered in the above entitled cause on, to-wit, the 4 day of March, A. D. 1935, and are about to apply to the said District Court of the United States for the Northeastern Division of the Northern District of Alabama for the allowance of such an appeal. They hereby notify each of you to join in said appeal if you so desire.

James Lawrence Fly
William C. Fitts, Jr.
Solicitors for the Defendants,
Tennessee Valley Authority,
Arthur E. Morgan,
Harcourt A. Morgan,
David E. Lilienthal,
Electric Home & Farm Authority, Inc.

Service of the above notice is accepted this 6 day of April, 1935.

W. H. Mitchell
Solicitor for the City of Florence and the City of Decatur.

J. E. Deloney, Jr.
Solicitor for the Defendant, City of Tuscumbia.

Stockton Cooke
Solicitor for the Defendant, City of Sheffield.

Martin, Turner & McWhorter
Solicitor for the Defendant, Alabama Power Company.

Courtland Palmer
J. T. Stokely
Solicitor for the Defendant, Chemical Bank & Trust Company.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.
} In Equity No. 355

Filed April 11, 1935.

PETITION FOR APPEAL

Come now the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilien-

thal and Electric Home and Farm Authority, Inc., by their solicitors of record, and hereby enter their appeal from the final decree entered in this cause on the 4th day of March, 1935, granting a permanent injunction in the above-entitled cause, to the United States Circuit Court of Appeals for the Fifth Circuit for the reasons specified in the assignment of errors which is filed herewith, and pray that such appeal be allowed without bond, and that citation issue as provided by law, and that a transcript of the record, proceedings, papers and evidence, upon which said final decree was made, duly authenticated, be sent to the United States Circuit Court of Appeals for the Fifth Circuit, sitting at New Orleans, Louisiana, for the purpose of having reviewed the ruling and decision in said final decree contained, and the errors therein corrected and said final decree reversed according to law.

The defendants above named further pray that the Court in the order allowing the appeal will grant leave to these defendants to appeal and assign errors separately without joining any of the other defendants in said appeal or assignment of errors.

James Lawrence Fly
William C. Fitts, Jr.
Solicitors for the defendants
Tennessee Valley Authority
Arthur E. Morgan
Harcourt A. Morgan
David E. Lilienthal and
Electric Home and Farm Authority, Inc.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al,
Plaintiffs,
vs.
Tennessee Valley Authority, et al,
Defendants.
In Equity No. 355

Filed April 11, 1935.

ORDER ALLOWING APPEAL

Upon petition of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilienthal and Electric Home & Farm Authority, Inc., it is hereby ordered as follows:

1. That an appeal without bond is hereby allowed in the above-entitled cause to the said defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilienthal and Electric Home & Farm Authority, Inc. to the United States Circuit Court of Appeals for the Fifth Circuit from the final decree heretofore entered in said cause on the to-wit: the fourth day of March, 1935.

2. It appearing to the Court that the final decree from which this appeal is prayed ran against all of the defendants, it is hereby ordered that the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilienthal and Electric Home & Farm Authority, Inc., have leave to appeal and assign errors separately, without joining any of the other defendants in said appeal or assignment of errors.

3. That a citation be issued, directed to George Ash-

wander, Wm. M. Browder, A. C. Garber, Joseph R. Cook, Jr., Bessie M. Gray, C. H. Gray, Clifford L. Lamar, Mary P. London, F. W. Murray, Eugene C. Morgan, Joseph A. Norman, C. L. Torbert, R. H. Woodrow, Tutwiler Investment Company, a Corporation, plaintiffs herein, to be and appear in said United States Circuit Court of Appeals for the Fifth Circuit, sitting at New Orleans, Louisiana, within thirty days from the day of taking said appeal, as required by law.

4. That the Clerk of this Court transcribe, certify and transmit to said United States Circuit Court of Appeals for the Fifth Circuit, a true and complete transcript of the record, exhibits, evidence and all other proceedings in this cause as required by law.

Done and ordered at Birmingham, Alabama, this 11th day of April, A. D. 1935.

W. I. Grubb
Judge of United States District Court in and for the Northeastern Division of the Northern District of Alabama.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al, Plaintiffs,
vs.
Tennessee Valley Authority, et al, Defendants.
} In Equity No. 355

Filed April 11, 1935.

CITATION

United States of America

To George Ashwander, Wm. M. Browder, A. C. Garber, Joseph R. Cook, Jr., Bessie M. Gray, C. H. Gray, Clifford L. Lamar, Mary P. London, F. W. Murray, Eugene C. Morgan, Joseph A. Norman, C. L. Torbert, R. H. Woodrow, Tutwiler Investment Company, a Corporation:

Greetings: You and each of you are hereby cited and admonished to be and appear in the United States Circuit Court of Appeals for the Fifth Circuit at the City of New Orleans, State of Louisiana, within thirty days from the 11th day of April, A. D. 1935, pursuant to an order allowing an appeal from the United States District Court for the Northeastern Division of the Northern District of Alabama, to the United States Circuit Court of Appeals for the Fifth Circuit from the final decree entered in the above-entitled cause on, to-wit: the fourth day of March, A. D. 1935, wherein Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, David E. Lilienthal and Electric Home & Farm Authority, are appellants and you are the

appellees, to show cause, if any there be, why said final decree rendered against said appellants should not be reversed and corrected and why speedy justice should not be done to the parties in that behalf.

Witness the Honorable W. I. Grubb, Judge of the District Court of the United States for the Northeastern Division of the Northern District of Alabama, this 11th day of April, A. D. 1935.

W. I. Grubb,
District Judge as Aforesaid.

We, the undersigned, as solicitors of record for the plaintiffs in the above-entitled cause, do hereby accept and admit service of the above and foregoing citation, this 11th day of April, 1935.

Cabaniss & Johnston
Solicitors of Record for Plaintiffs.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al Plaintiffs, v. Tennessee Valley Authority, et al Defendants.	}	In Equity No. 355

Filed April 11, 1935.

ASSIGNMENT OF ERRORS

Now come Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal, defendants in the above styled cause, by their solicitors, and file

and make the following assignment of errors upon which they will rely in the prosecution of the appeal in the above styled cause from the final decree heretofore entered in this cause, to-wit:

1. The District Court erred in entering the final decree herein.

2. The District Court erred in entering the final decree whereby it annulled and cancelled the contract of January 4, 1934, and the supplemental contracts and agreements referred to in Section 2 of the final decree, and in granting the permanent injunction set out in said decree.

3. The District Court erred in entertaining the cause below and in entering the final decree herein for the reason that this suit presents no justiciable controversy between the plaintiffs and the defendants herein.

4. The District Court erred in denying and overruling the motion of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal, to dismiss the original bill of complaint in the order dated November 28, 1934.

5. The District Court erred in overruling and denying by the order dated November 28, 1934, the motion of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan, and David E. Lilienthal, to strike from the bill of complaint certain impertinent, irrelevant and redundant averments thereof.

6. The District Court erred in admitting in evidence over the objections of the defendants duly and legally made the public speeches of the directors and other employees of the defendant Tennessee Valley Authority, which speeches are included in the answer of the defendant Tennessee Val-

ley Authority to Interrogatory 2-a introduced in evidence by the plaintiffs. Objections were separately interposed as to each of said speeches and each and every ruling of the Court upon said separate objections is here separately assigned as error.

7. The District Court erred in admitting in evidence over the objections of the defendants duly and legally made the press releases of the directors and other employees of the defendant Tennessee Valley Authority, which releases are included in the answer of the defendant Tennessee Valley Authority to Interrogatory 2-a introduced in evidence by the plaintiffs. Objections were separately interposed as to each of said press releases and each and every ruling of the Court upon said separate objections is here separately assigned as error.

8. The District Court erred in admitting in evidence over the objections of the defendants duly and legally made the excerpts from the minutes of meetings of the Board of Directors of the Tennessee Valley Authority introduced in evidence as plaintiffs' Exhibits 1 through 11, inclusive, 39, 41, 41-a through 41-r, inclusive. Objections were interposed by the defendants separately as to each of said excerpts and each and every ruling of the Court upon said separate objections is here assigned as error.

9. The District Court erred in overruling the objection of the defendants interposed to the following question propounded by counsel for the plaintiffs to the witness, Ezra B. Whitman: "Will you state what the situation is with reference to capacity in that area and market, that is, the surplus in that area?" The District Court also erred in admitting in evidence over the objections of the defendants duly and properly made all of the testimony of the

witness Ezra B. Whitman following the question above set out relating to the subject matter of that question.

10. The District Court erred in overruling the objection interposed by defendants to the following question propounded by counsel for the plaintiffs to the witness O. G. Thurlow: "Now can you give us the surplus for 1934 in terms of the Commonwealth and Southern demand?"

11. The District Court erred in failing to make findings of fact and conclusions of law sufficient to comply with Equity Rule 70½.

12. The District Court erred in overruling and denying the motion of the defendants praying for the specific findings of fact and conclusions of law proposed therein.

13. The District Court erred in making findings of fact numbered 1 thru 118 inclusive and the Court erred in each of said findings.

Wherefore, the said parties named in the first paragraph of this Assignment of Errors pray that the said final decree heretofore entered by said Court be reversed with instructions to the District Court to dismiss the Bill of Complaint.

James Lawrence Fly
William C. Fitts, Jr.
Solicitors for the defendants,
Tennessee Valley Authority,
Arthur E. Morgan,
Harcourt A. Morgan, and
David E. Lilienthal.

Presented April 11, 1935.
W. I. Grubb,
District Judge.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al Plaintiffs, vs. Tennessee Valley Authority, et al Defendants.	}	In Equity No. 355

Filed April 11, 1935.

ASSIGNMENT OF ERRORS OF ELECTRIC HOME AND FARM AUTHORITY, INC.

Now comes Electric Home and Farm Authority, Inc. one of the defendants in the above styled cause by its solicitors and assigning errors separately files and makes the following assignment of errors upon which it will rely in the prosecution of the appeal in the above styled cause from the final decree heretofore entered, to-wit:

1. The District Court erred in entering the final decree herein whereby it annulled and cancelled the contract of May 21, 1934 between defendant Electric Home and Farm Authority, Inc. and Alabama Power Company.

2. The District Court erred in overruling and denying the motion of the defendant Electric Home and Farm Authority, Inc. to quash the service of the subpoena.

Wherefore, the said party named in the first paragraph of this Assignment of Errors prays that the said final decree heretofore entered by said Court be reversed with in-

structions to the District Court to dismiss the Bill of Complaint.

James Lawrence Fly
William C. Fitts, Jr.
Solicitors for the defendant, Electric Home and Farm Authority, Inc.

Presented April 11, 1935.
W. I. Grubb
District Judge.

In the United States District Court for the Northeastern Division of the Northern District of Alabama

George Ashwander, et al
Plaintiffs,
v.
Tennessee Valley Authority, et al
Defendants.
} In Equity No. 355

Filed April 11, 1935.

PRAECIPE FOR TRANSCRIPT

To the Clerk of the United States District Court for the Northeastern Division of the Northern District of Alabama:

You will please prepare and certify a transcript of the record in the above-entitled cause, for use in the United States Circuit Court of Appeals for the Fifth Circuit, pursuant to an appeal in said cause taken and allowed the defendants, and in making up said transcript observe the following directions and include therein the following pleadings and proceedings, to-wit:

1. The original Bill of Complaint with exhibits attached thereto numbered from one to thirteen inclusive.

2. The petition and bond of the defendants, Tennessee Valley Authority and Electric Home and Farm Authority, Inc. for removal of the cause from the Circuit Court of Limestone County, Alabama to the United States District Court for the Northeastern Division of the Northern District of Alabama.

3. The Order of Removal signed by Judge Horton.

4. The motion of the defendant Electric Home and Farm Authority, Inc. to quash service of the subpoena, together with the affidavit of G. D. Munger with the exhibits attached thereto, filed Nov. 8, 1934.

5. The motion of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal to dismiss the Bill of Complaint, filed Nov. 8, 1934.

6. The motion of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal to strike certain portions of the Bill of Complaint, filed Nov. 16, 1934.

7. The motion of the defendants, City of Florence, City of Sheffield and City of Tuscumbia to dismiss the Bill of Complaint, filed Nov. 10, 1934.

8. The motion of the defendant, City of Athens, to dismiss the Bill of Complaint, filed Nov. 15, 1934.

9. The motion of the other defendant towns to dismiss the Bill of Complaint, filed Nov. 12, 1934.

10. The order overruling and denying the motion of the defendants to strike portions of the Bill of Complaint, and

the various motions of the defendants to dismiss the Bill of Complaint, filed Nov. 28, 1934.

11. The opinion of the Court in overruling and denying the motion of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal to dismiss the Bill of Complaint, filed Nov. 28, 1934.

12. The answer of the defendant, Alabama Power Company, to the Bill of Complaint, filed Nov. 9, 1934.

13. The answer of the defendant, Chemical Bank and Trust Company, to the Bill of Complaint, filed Dec. 15, 1934.

14. The answer of the defendant, City of Florence, to the Bill of Complaint, filed Jan. 2, 1935.

15. The answer of the defendants, City of Sheffield and City of Tuscumbia, to the Bill of Complaint, filed Dec. 29, 1934.

16. The answer of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal and Electric Home and Farm Authority, Inc. to the Bill of Complaint, filed Dec. 29, 1934.

16a. Plaintiff's motion for temporary restraining order, filed Jan. 9, 1935.

17. The Temporary Restraining Order of January 9, 1935.

18. The memorandum opinion of the Court upon the motion to dissolve the Temporary Restraining Order of January 9, 1935.

18a. Motions of City of Decatur, City of Florence, City

of Sheffield and City of Tuscumbia to dissolve temporary restraining order.

18b. Stipulation as to documents.

19. The amended answer of the defendant, Alabama Power Company, to the Bill of Complaint, filed Jan. 25, 1935.

20. The amended and supplemental answer of the defendants, Tennessee Valley Authority, Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal and Electric Home and Farm Authority, Inc. to the Bill of Company, filed Jan. 25, 1935.

21. The corrected oral opinion of the Court filed February 26, 1935.

22. The order continuing the cause under advisement for findings of fact and conclusions of law, filed March 2, 1935.

23. The final decree, filed March 2, 1935.

24. Motion of the defendants, Tennessee Valley Authority, Electric Home and Farm Authority, Inc., Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal for findings of fact and conclusions of law, filed March 9, 1935.

25. The findings of fact and conclusions of law adopted by the Court, filed April 11, 1935.

25½. Notice of appeal to co-defendants with acceptance of service.

26. The petition for appeal.

27. The order granting the appeal.

28. The assignment of errors.

29. The citation and acceptance of service.

30. The narrative of the evidence.

31. A copy of this praecipe with acceptance of service.

32. The certificate of the Clerk of this Court to the transcript.

You may omit all other papers and documents.

James Lawrence Fly,
Solicitor for Defendants, Tennessee Valley Authority, Electric Home and Farm Authority, Inc., Arthur E. Morgan, Harcourt A. Morgan and David E. Lilienthal.

To: Messrs. Cabaniss and Johnston
Solicitors of Record for the Plaintiffs:

Please take notice that we will file on this 11th day of April, 1935, with the Clerk of the United States District Court for the Northeastern Division of the Northern District of Alabama the above Praecipe.

James Lawrence Fly
Solicitor for Defendants

We hereby acknowledge receipt of a copy of this Praecipe on this 11th day of April, 1935.

Cabaniss & Johnston
Solicitors for Plaintiffs